Compressed Air Magazine

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AUGUST, 1923

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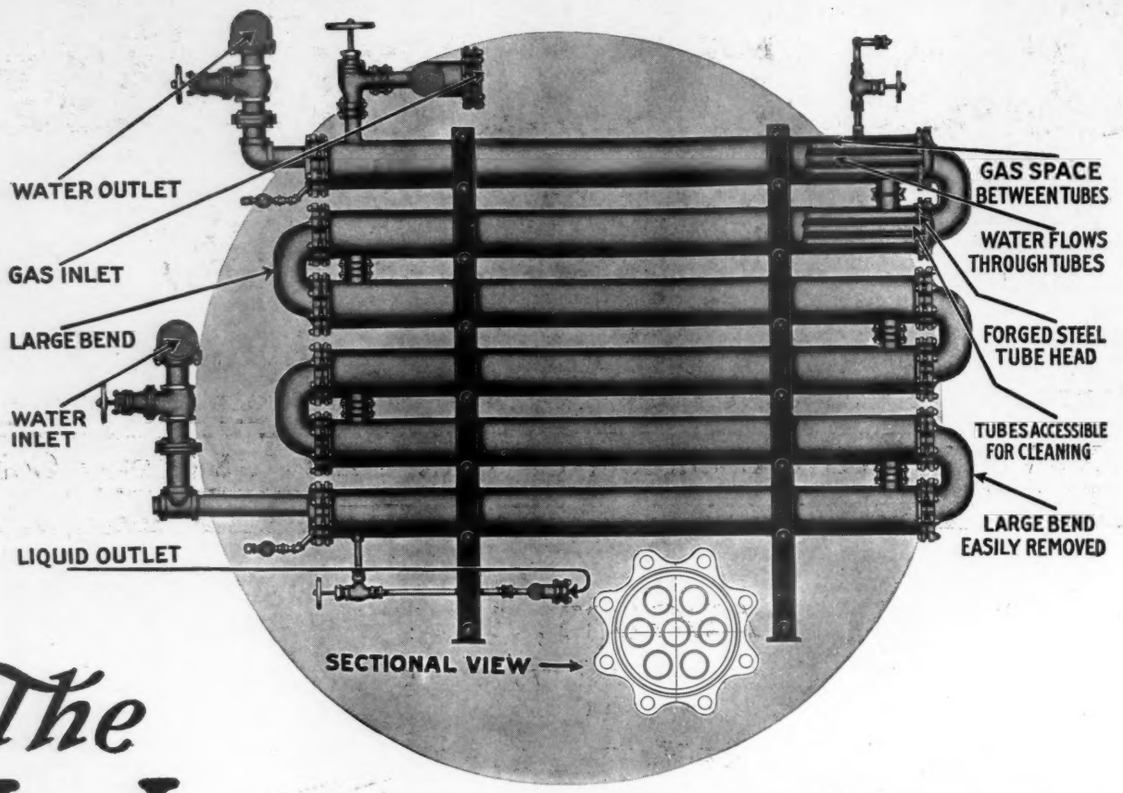

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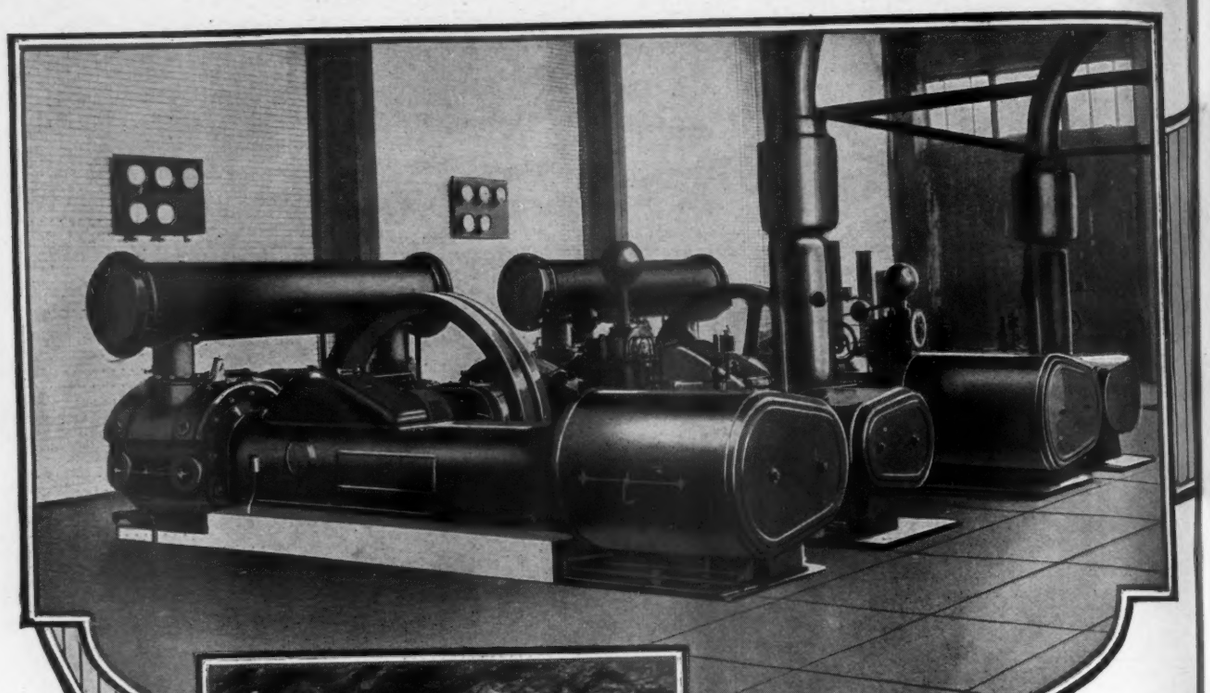

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VOL. XXVIII, NO. VIII

AUGUST, 1923

The World's Greatest Garnet Quarry

Mining a High-Grade Abrasive With Which to Smooth and to Polish Manufactured Products

By ROBERT G. SKERRETT

TUCKED AWAY in the heart of the Adirondack Mountains, near beautiful Thirteenth Lake, and about three and a half miles to the south and west of the Village of North River, Warren County, N. Y., are the plant and the associate properties of the North River Garnet Company, America's largest producer of abrasive garnet.

The present operations date from 1905, and work has been carried on there without a break since under the supervision of Mr. Frank C. Hooper, manager and part owner of the company and one of the pioneers of the industry in question. To be exact, Mr. Hooper established an experimental mill not far away in 1893, and a year later he organized his first commercial plant in a part of Essex County which now is embraced by Hamilton County, N. Y. For two decades this was the only garnet concentrating plant in the world. Step by step, Mr. Hooper has improved his methods and adapted facilities so that it is now possible for him to turn out garnet concentrates which are exceptionally clean—something that is recognized as a distinctive achievement in view of the fact that the difference in specific gravity between the garnet and the gangue is as close as 3/10ths of a point.

The deposit is a fairly extensive one well up on the mountainside, and the ore, to quote the geologist, "is a garnetiferous gneiss containing almandite garnet in grains from a small fraction of an inch to four or five inches in diameter," though pockets or crystals weighing 75 pounds are found at times. The average garnet content of the rock is probably between 8 per cent. and 10 per cent., which means that a large quantity of raw material must be handled in order to yield a single ton of marketable abrasive. But this apparent handicap is more than offset by the excellence of the product.

According to the United States Bureau of Mines, well-nigh all types of garnet may be used for gemstones when found sufficiently clear and transparent, but only the almandite variety has been proved by actual use to be a high-grade abrasive. While it is true that New Hampshire, Pennsylvania, and Connecticut have heretofore produced small quantities of garnet, still New York State remains preëminent in the production of this natural abrasive; and the North River ore enjoys the reputation for superiority owing to conditions surrounding its birth eons ago when the earth's crust in that neighborhood underwent tremendous movements which, combined with several different intrusions of igneous rock, thoroughly transformed the ancient Grenville sediments.

THE RUDDY garnet is known to most of us as a semi-precious stone that figures not infrequently as a gem in finger rings or as the colorful setting in other forms of jewelry. Instinctively, therefore, we think of the garnet as a possible adornment and little realize that this is the least valuable of the uses to which it is put.

It will probably surprise a great many people to learn that we mine garnets in this country for far more practical purposes, such, for instance, as for the abrasive coatings of certain kinds of sandpapers and for some of the finishing processes in the production of plate glass.

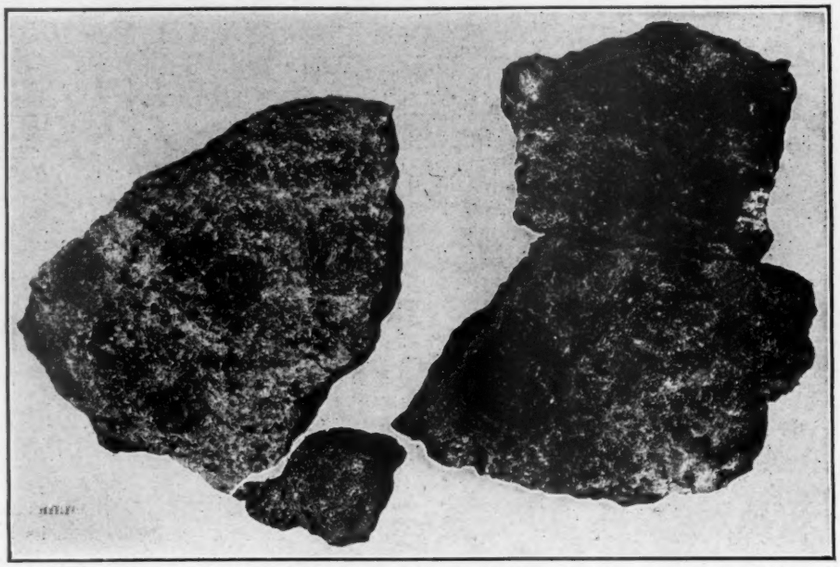
The accompanying story describes how abrasive garnet is mined at probably the foremost mine of its kind in the United States and then separated from the enveloping rock by milling methods that have been brought to a notable degree of effectiveness. Both in getting the garnet out of the ground and in putting it through succeeding stages of preparation, we shall see that compressed air is an important and even an indispensable aid.

The commercial value of abrasive garnet depends upon its hardness, toughness, manner of fracturing, and purity. The grains, crystals, or masses of the garnet must be large enough to yield, when crushed and screened, particles of sharply angular form and of varying sizes to meet the requirements for different grades of abrasive papers. Therefore, a laminated garnet, which will break up into relatively sharp, angular grains, is most to be desired. It is the sharp cutting edges of the abrasive that do the work for which garnet papers are employed.

Two types of veins, characterized by the relative amounts of hornblende and feldspar in the gangue, are being worked in this district. In the Hooper deposit, the feldspars are predominant; and the vein is apparently of an older type, lying as it does in a geological horizon several hundred feet deeper than the hornblende type. The well defined cleavage found in the Adirondack garnets, compared with the lack of a similarly developed cleavage in almandite garnet discovered in other localities, is undoubtedly due to the extreme changes that these rocks have undergone and to the compact non-porous rock forming the gangue. In other words, there was a clash between the forces of crystallization in the garnet, while trying to expand into a perfect crystal, and the resistance to that expansion offered by the non-porous rock which was deeply buried when this action was taking place. The resultant was an irregular-shaped ball or nodule of garnet with a cleavage that has not been observed in this mineral found elsewhere. Had the garnet been born in a porous, yielding rock like a mica schist, for instance, it would have lacked the distinctive cleavage. Thus, the very stresses which impaired the garnet as a potential gem at the time of its genesis made it far more valuable to man industrially.

Garnet paper as a competitor of quartz sandpaper was first brought out in the "eighties," and has won widening recognition ever since because of qualities which distinguish the garnet abrasive from the quartz-sand abrasive. Mr. Raymond B. Ladoo, a mineral technologist in the Government service, says: "The difference in the abrasive value of garnet and quartz sand is greater than is indicated by the

hardness classification of the Mohs scale. On hard woods, such as oak, maple, hickory, chestnut, walnut, and mahogany, some authorities state that quartz is scarcely better than 60 per cent. as efficient as garnet. On some white pine it is about 85 per cent. as efficient, and on gummy yellow pine the quartz sand is about the equal of garnet."



Typical pieces of the garnet-bearing rock. The darker, circular areas are nodules of almandite garnet.

In latter years, the consumption of garnet in the United States has been around 6,500 tons annually. Of this about 6,000 tons has been used in manufacturing garnet paper and cloth, and substantially 500 tons has been employed as loose grain for miscellaneous grinding and polishing operations. Spain is the only other country furnishing any important quantities of garnet; and the Spanish production is said to exceed but rarely 2,500 tons per annum—most of this output finding a market in America. Inasmuch as the deposit near Thirteenth Lake yields at present approximately 5,000 tons in a twelvemonth, or about 80 per cent. of the annual consumption, the significance of the activities of the North River Garnet Company becomes evident.

Producers like the North River Garnet Company commonly ship their commodity as garnet concentrates rather than as finished grains graded to sizes ready for use. This is because most of the manufacturers engaged in turning out abrasive cloths or papers have their own crushing, grinding, and screening equipment; and the crude concentrated garnet reaches them packed in bags holding from 100 to 150 pounds.

Now let us imagine ourselves at Thirteenth Lake and up on the mountain slope where the garnet-bearing gneiss has been uncovered by Mr. Hooper's men. The height of the quarry face and the scope of the excavation are clearly indicated in some of the accompanying illustrations. As can be seen, the garnet rock is drilled by means of pneumatic tools and blasted out. The air for this purpose is supplied by a plant composed of two "Imperial" type X, steam-driven compressors, each having 2-stage air-compressing cylinders and compound steam cylinders. There is a smaller or reserve auxiliary unit. Inasmuch as operations are carried on the year through, fully 500 feet of the air line piping is exposed to the atmosphere in the open cut of the quarry, and is called upon to furnish air to the pneumatic drills when the temperature is 30 or 40 degrees below zero. To prevent moisture in the pipes from freezing, the line has been fitted with a Lunkenheimer No. 6½ Emblem sight feed cup from which wood alcohol can be fed, drop by drop, into the main. A pint of alcohol daily will keep the line clear in the coldest weather.

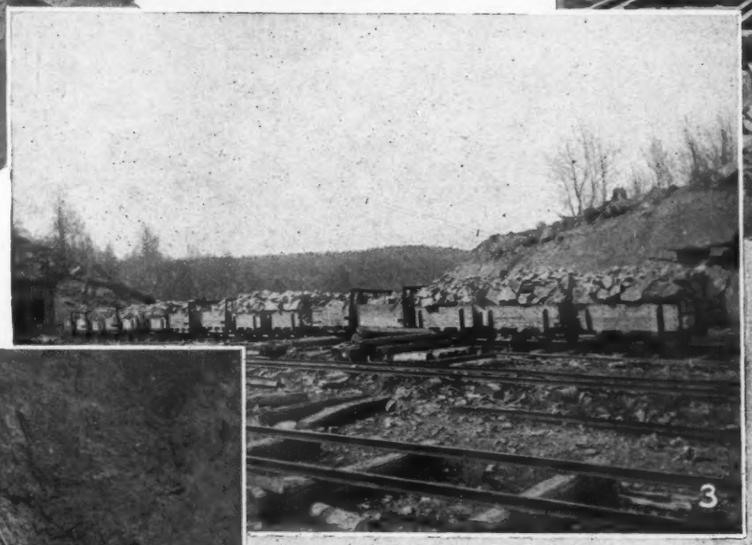
In addition to providing motive power for the tools and for the "Leyner" sharpener, with which the blacksmith shop is now equipped, compressed air is utilized in carrying on other operations directly associated with the quarry. The rock, after blasting, is loaded into cars both by hand and by a steam shovel, and an air-driven hoisting engine serves to haul the cars from the scales to the storage yard—moving the vehicles a distance of 100 yards. Each car, when loaded, carries about nine tons of rock. When the loading is done by hand, which is necessary under some circumstances, two men lift a large rock on a bent bar while a third man balances the rock; and they are so expert at this that it is practicable for each loader to average anywhere from 16 to 20 tons a day. Experienced hands do load from 25 to 27 tons in this way. Another hoisting engine, also air driven, is located on the platform leading to the crusher chute where it helps in handling the dump cars.

The rock, just as it has been shattered by blasting, is moved in cars from the working level of the quarry to a chute leading to the primary crusher intakes. The ore drops onto a grid or grizzly fashioned of railroad rails spaced so as to leave openings four inches wide. Should any of the pieces of rock be too large to be fed to the crushers they are lifted out for breaking, by means of an air-operated piston hoist. The ore, after dropping by gravity through the grids, joins the product from the primary crusher and is fed to two smaller jaw crushers. From the crushers, the rock goes through four sets of rolls; and when issuing from the latter the broken material ranges in size from one-quarter inch downward. All undersize material coming from the rolls is disposed of by shaking screens. After leaving the screens, the ground ore is run to a storage bin and fed to a roughing machine which gets rid of the coarse, waste rock. Next, the partly concentrated ore descends through iron-lined chutes for further treatment in the separating department of the plant.

Like the plants of kindred industries, the buildings of the mill of the North River Garnet Company are placed successively upon the hillside so that the raw materials can descend by gravity through each operating stage until the granulated rock arrives at the vanning jigs, which effect most of the separation. To the layman, the work in the separating department is probably the most interesting, because the average person naturally wonders how the garnet particles can be separated from the undesirable impurities, such as the pulverized or granular feldspar and black hornblende. This work must be done carefully and thoroughly in order to insure a clean product capable of satisfying market requirements. To enable the uninformed to better grasp the nicety of the task, it should

Looking west from the top of the quarry toward the settling basin and beyond to Thirteenth Lake.

GARNET MINING IN THE HEART OF THE ADIRONDACKS



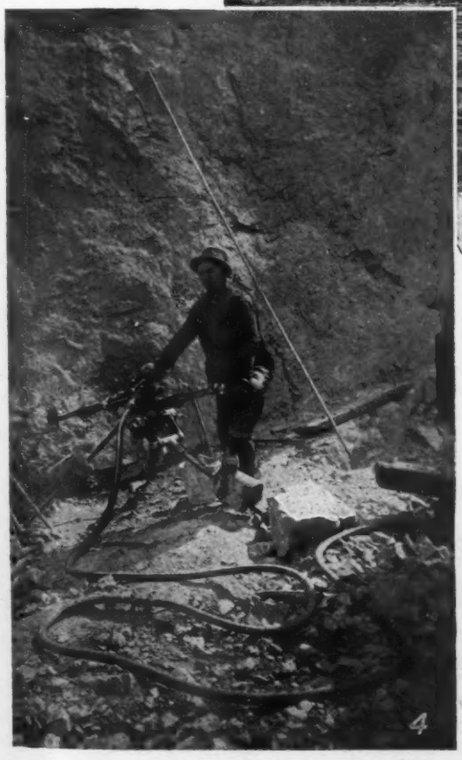
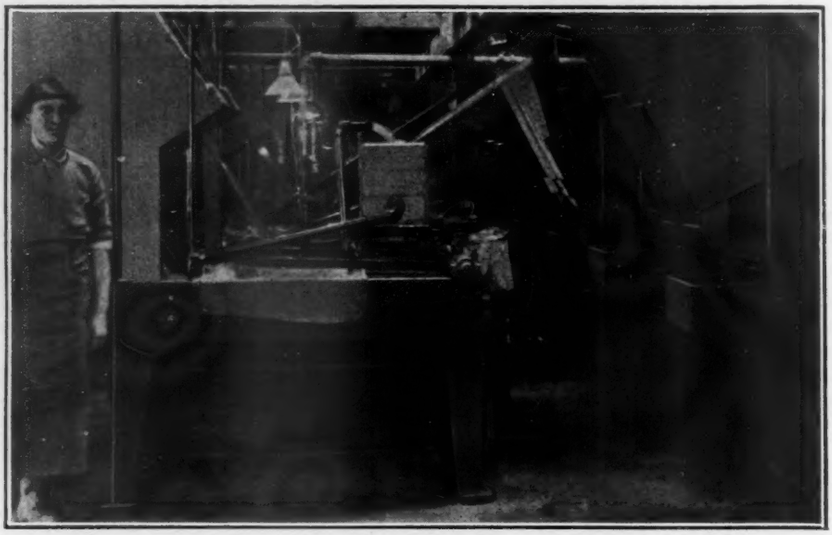


Fig. 1—The steam shovel has speeded up the work of handling the blasted garnet-bearing rock. Fig. 2—Some men become so skilled in loading rock in this manner that they are able to deal with from 25 to 27 tons a day. Fig. 3—The string of rock-laden cars in the storage yard. These cars are drawn into position by an air-operated hoisting engine. Fig. 4—An Ingersoll-Rand C110 "Butterfly" drill at work on the face of the garnet quarry. Fig. 5—An air-driven hoisting engine which pulls the cars at the northern end of the storage yard adjacent to the chute leading to the primary crushers.



A battery of vannnig jigs in the separating department. Here is where the garnet granules are washed and shaken free from the gangue or ground rock.

be recalled that the specific gravity of black hornblende is but very little below that of garnet; and it is the difference in specific gravity between the desirable and the undesirable materials that makes it possible to effect their separation.

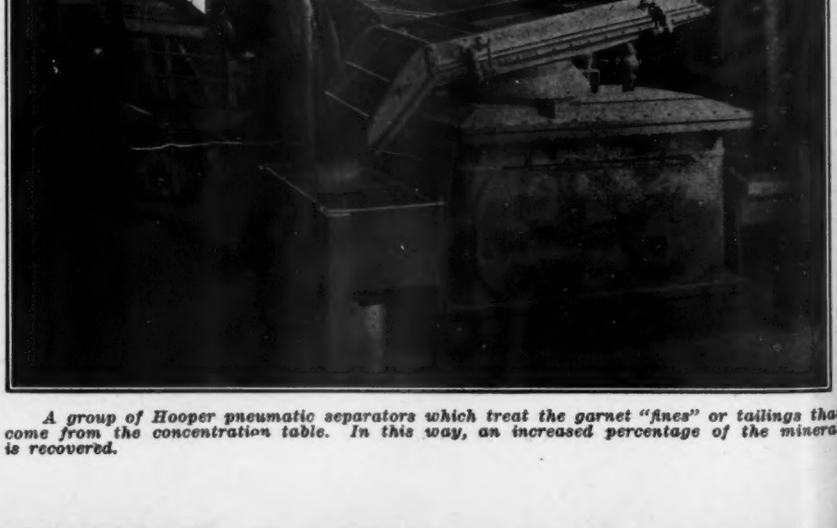
After much experimenting, Mr. Hooper has so modified his vanning jig, which was the first vanning jig ever invented, that he is able to juggle successfuliy with these differences in gravity despite the narrow margin mentioned; but for business reasons he does not desire to take the world into his confidence. However, in a general way, we are permitted to describe this part of the process. The vanning jigs at the plant consist in each case of the following essential elements: A wire screen, of definite mesh, spread across the bottom of an oblong cast-iron frame so hung that it may be given an up-and-down motion at one end by a supporting rod actuated by a cam—the opposite end of the frame being pivoted. The screen is also oscillated longitudinally; and it is suspended in a steel tank filled with water into which the screen dips intermittently.

The screen is charged at its middle with the raw, ground ore; and the effect of the washing action of the water and the vertical and oscillating movements of the screen—combined with the differences in specific gravity—is to cause the garnet granules to work up hill on the screen and to successively move away from the feldspar and the hornblende. From time to time, the attendant scoops out the rich red garnet sand and pebbles and places them in a convenient box-like pocket secured to the near-by end of the wooden tank. The sludge or refuse remaining in the screen is automatically discharged over the lower end of the screen frame into the waste launder. The material which drops through the screen and into the water is mechanically disposed of by a bucket conveyer which delivers the stuff to the next vanning jig, which is equipped with a screen of closer mesh. Thus, in four stages, the ore is subjected to wet screening.

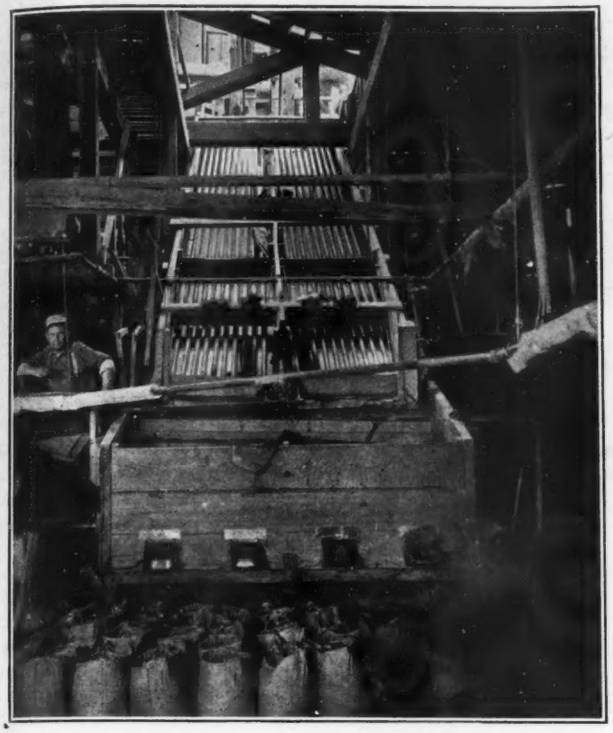
After leaving the last of the vanning jigs, the finer garnet residue or tailings are treated on a concentration table. Taking the different strata as they appear on the table from the top downward to the lowest riffle, there is first iron, then garnet, and, finally, the successive ingredients of the sludge or pulverized rock. The garnet obtained from the concentration table is, subsequently, treated dry by a Hooper pneumatic separator. Here, again, compressed air does a helpful service. The separator has a diaphram of broadcloth onto which the garnet "fines" are fed. The mineral on the cloth is given a pulsating motion by blasts of air directed against it from the under side. The broadcloth is mounted upon a frame and held in a slanting position—dipping from left to right. Just above the fabric there is a series of thin metal strips, set at slightly different heights above the textile, and forming a number of runways. These vanes, in combination with the motion imparted to the mineral by the air pulsations, impel the garnet particles downward and sidewise, distributing them in the several runways agreeably to size and weight. from this ingenious machine the garnet drops into bags.

The garnet fines, so reclaimed, are mixed

In order to take care of the steels that have to be handled daily, the blacksmith shop has recently been equipped with a pneumatically operated "Leyner" sharpener.



A group of Hooper pneumatic separators which treat the garnet "fines" or tailings that come from the concentration table. In this way, an increased percentage of the mineral is recovered.



The inclined drier which makes the wet garnet concentrates ready for bagging. The mineral is subsequently screened and graded in sizes by the abrasive-paper manufacturers.

with the coarser and the wet concentrates from the various vanning jigs, and all the material is then elevated to a drier. The drier is a shallow, inclined box fitted with a grid of steam coils arranged longitudinally; and as the garnet dries it slides to the bottom and is led into sacks which are promptly tied and made ready for shipping. While the foregoing procedure may seem rather simple, as a matter of fact it is somewhat complex and demands skilful supervision at certain stages of execution. Commercial success depends upon the degree of the extraction of the garnet from the mother rock; and anywhere from ten to fifteen tons of rock must be handled to obtain a single ton of marketable concentrate. Mr. Hooper says that the recovery of garnet from the rock averages around 80 per cent. of the garnet content. This is an excellent performance.

The garnet nodules found in the neighborhood of Thirteenth Lake are embedded in pockets in the rock, and a hammer blow is often sufficient to cause these aggregations to drop free. In a measure, the formation lends itself that much easier to crushing and to subsequent separation. Occasionally, solid crystals of garnet weighing more than a ton are encountered in quarrying. The largest garnet crystals found in the Bohemian mines—which are used for jewelry—do not exceed an inch in maximum dimension. Mr. Ladoo states that while "the hardness ordinarily attributed to garnet varies from 6.5 to 7.5, the best types of abrasive garnet have a hardness of nearly 8.0. In order for the garnet to be of value, therefore, the hardness should be at least 7.5." The garnet mined by the North River Garnet Company satisfies this requirement—having the same hardness as topaz.

Until within the past few months, drilling and blasting operations have been limited to the single quarry located on the mountainside well above the mill. As that outcropping is being cleared away, Mr. Hopper has deemed it advisable to attack the deposit at a lower level, and he has therefore built a cableway capable of spanning both the upper and the lower levels of the ledge so that it will be practicable to handle and to load cars on both of them—the tracks running parallel and delivering the quarried rock to the crusher chutes.

The primary source of power is steam supplied by a battery of coal-burning Sterling boilers, the fuel for which has to be hauled from rail head on the Delaware & Hudson line at the Village of North River. Water for the plant, derived from rains and melting snow, is impounded in reservoirs or ponds a short distance below the mill. This water is used over and over again; and after leaving the vanning jigs it is piped to the settling basin whence it is pumped back to the mineral separators for further service.

Because of the comparatively isolated scene of its activities, the North River Garnet Company has established an industrial settlement where most of the workers live. Everything within reason is done for the welfare and the happiness of the operatives and their families; and as Mr. Hooper spends most of his time on the property he is able to exercise a sympathetic supervision over the community. The working force at the mine and the mill numbers 110 men.

NATALITE

NATALITE is the name of a promising substitute for gasoline and is coming into actual use—in fact, is settling right down to business. It is a sugar-cane distillate made largely from waste material.

According to a report to the Department of Commerce, the South African Railways have just awarded The Natal By-Products, Ltd., the manufacturers of natalite, a six months' contract for the fuel for use throughout their motor-transport service. It will be supplied at 1s. 4d. per imperial gallon (26.7 cents for a United States gallon) free on board at Mearbank, near Durban. It is understood that this is about one-third under the lowest local bid for gasoline. The producers of natalite claim that their product is 90 per cent. efficient as compared with gasoline; and, even discounting this figure, it is likely to be further heard from in the near future.

NOVEL HIGH-PRESSURE STEAM BOILER

Mr. Viktor Plomqvist, a Swedish engineer, has recently patented a high-pressure boiler named the "Atmos." It is of novel design—its chief characteristic being that the steam is generated in rotating elements which are fed with boiling water from a stationary heater.

There is a system of tubes rotating at great speed, which has the effect of keeping the inner surfaces continuously covered with boiling water unmixed with steam—the steam being liberated later—whereby the generating tubes are always effectively protected. It is possible to generate steam at a pressure up to 150 atmospheres, 2,200 pounds, or higher without injury to the rotating system. A saving of 20 per cent. in fuel is claimed; and the boiler is also lighter and takes up less space than the familiar types.

The mill as seen from the north and looking west toward Thirteenth Lake. Situated on the hillside, the rock is fed by gravity from one department of the plant to the other.

PUSHING ALONG BIG POWER PROJECT WITH GUNITE

AFTER FIVE years of investigational work in the field and in the office, the Western States Gas & Electric Company of California took the first step, early this year, in the construction of a 100,000-H.P. hydro-electric development, which is to be known as the El Dorado plant.

Guniting the core wall of the earth dam at Twin Lakes.

Parts of El Dorado ditch are being enlarged and lined from the forebay above the new power house to the intake, a distance of 23 miles. In sections of the ditch, where leakage is bad, a concrete lining is being placed; and in this work a rather novel process, developed by engineers of the Byllesby Engineering & Management Corporation, is being employed.

Large, semi-circular, reinforced-steel forms that will conform to the contours of the canal are erected and, upon completion, given a coating of gunite by means of the cement gun, as shown in one of our illustrations. After the concrete has hardened sufficiently, the finished forms are laid in the ditch while the water is running—the operating conditions requiring the maintenance of a steady flow to transport, among other things, the materials for the lining in tub-like boats from the head of the canal to the point of use. These carriers are then telescoped and hauled back to the base of supply by trucks.

At Twin Lakes the construction of a 45-foot main dirt dam and a 26-foot auxiliary earth dam with a reinforced-concrete core wall is well under way. Like in the case of the semi-circular forms, work on the core wall is being expedited by applying gunite by means of compressed air. Large electric lights, supplied with current by a 75-kilowatt portable generator, enable the job to be carried on throughout the 24 hours of the day.

Modeling with gunite, on steel forms, the semi-cylindrical reinforced-concrete slabs for ditch lining.

ANOTHER DIFFICULT SUBWAY JOB

ANOTHER important link in New York City's subway system will be taken in hand shortly. This is known officially as the Nassau Street Line in down-town Manhattan. The lowest bidder for the job was Patrick McGovern, Inc., whose contract price was put at $5,590,000 for the construction of Section No. 2 of this particular branch of the subway.

Section No. 2, the first to be started, will extend from a connection with the existing Montague Street tunnel of the Brooklyn Rapid Transit system at Broad and Water Streets, Manhattan, up Broad Street and thence under Nassau Street to a point near Liberty Street.

According to a statement issued by the Transit Commission, "The Nassau Street Line will be two-tracked throughout. Special provision has been made in the plans for the protection of the buildings along either side of narrow Nassau Street, the problem being similar to that which was successfully met and solved in the construction of the subway in William Street. While that work was conducted with a minimum of disturbance to buildings and with little or no discomfort to their occupants, many important improvements in methods of foundation work were developed that will further simplify the construction in Nassau Street. Actual new foundations were laid beneath many of the buildings along William Street. The Transit Commission's engineers believe that although there is more street traffic in Nassau than in William Street the work there can be constructed with even less neighborhood disturbance."

One thing is certain, the task will call for the exercise of much skill and great care in numerous instances, but inasmuch as the contractor has had extensive experience in this line of work he will undoubtedly be able to dispose of every difficulty speedily and successfully.

WATERPROOF SANDPAPER

THIS is one of those industrial facilities whose advent has been curiously delayed these many years. It has only recently been put upon the market; and it at once permits the use of the abrasive under damp or positively wet conditions. Painted, varnished, or enameled surfaces may be cleaned off without raising dust.

Both the front and the back of the paper are waterproofed in such a way that the paper does not become soft when wet; and the abrasive material does not come off. The paint or other substance which accumulates on the surface in the process of rubbing is easily washed off. The material costs more than the older kind, but it is said to last ten times as long.

Long-delayed tests of a 20,000-H. P. Pelton wheel at Seattle, Wash., have just been completed. Notwithstanding continuous service for a year and a half, the unit was found to be in perfect operative condition. Water measurements were made by a weir permanently installed. A satisfactory efficiency curve was obtained—the maximum exceeding 42 per cent.

Modern Equipment Augments Municipal Water Supply

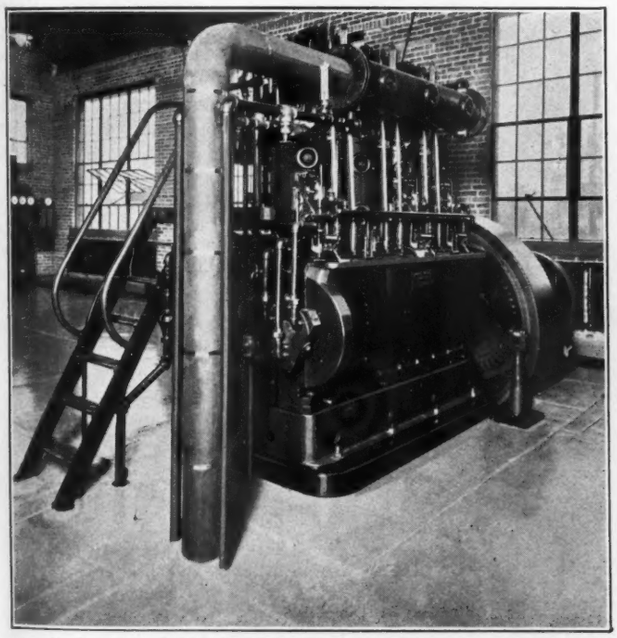
Elmhurst, an Enterprising Illinois City, Has Recently Added New and Interesting Features to Her Water Works Which Will Enable Her to Take Care of Her Needs for Years to Come

By C. W. MELCHER

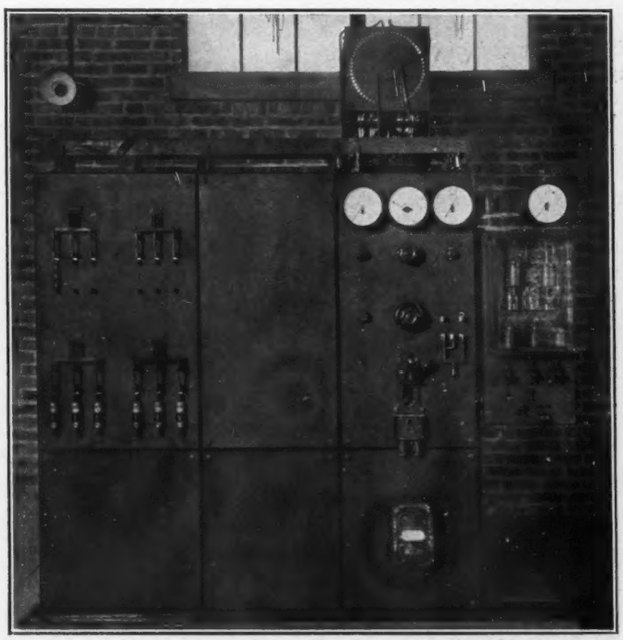
PUMPING water from deep wells into city mains against a head of 43 pounds gage, at a fuel cost of less than one cent per 1,000 gallons, is the fine showing made by the new municipal plant of the City of Elmhurst, Ill., one of Chicago's most progressive suburbs.

Prior to 1916, "Mammoth Spring"—four miles south of the city and owned and operated by a private corporation—was the source of supply. Water from that spring was distributed to users through a system of wooden mains that had been in service for 30 years. With the need for more water, the municipal authorities decided in 1916 to put down a 975-foot Artesian well, thus securing 185 gallons per minute by means of a deep-well pump. The water so obtained was sold to the company owning the franchise.

With an ample supply of water assured, Elmhurst began the replacement of the old wooden mains, and, by the end of 1920, had completed the laying of a system of cast-iron piping and had made the necessary connections with the consumers' service lines. This work was authorized by the City Council, and was accomplished under the direction of Mayor Otto W. Balgemann and Mr. H. S. Crockett, City Superintendent. On December 20, 1920, at the expiration of the private company's franchise, the water was shut off from the old wooden mains and turned into the new system. At this time there were 750 consumers; but twelve months later this number had increased to 1,600 with a maximum requirement of 705,000 gallons daily—each user being served through a meter.



A close-up of the 105-H. P. Price-Rathbun oil engine which drives a direct-connected alternating-current generator.



The switchboard which controls the electricity from an alternating-current generator that is direct connected to a 3-cylinder Price-Rathbun oil engine of 105-H. P.

Two years later, another well was sunk to a depth of 1,400 feet in order to supply the growing demand for water, and the city then arranged to take over the old mains from the private enterprise—paying for their use until the expiration of the franchise. So as to get the fullest measure of water, the new well was provided with an air-lift system using a 12x10-inch, motor- driven, Ingersoll-Rand compressor, a Harris air-lift pump and booster, and two 5-inch, motor-driven, Cameron centrifugal units for high-pressure service. This equipment, which was installed in the basement of the City Hall, made it possible to raise 620 gallons of water per minute.

To keep up with the augmented demands of the steadily expanding community, a new municipal water plant was authorized; and, after thorough investigation, the contract for the mechanical equipment was awarded to the Ingersoll-Rand Company. A brick power house was erected; and, upon the installation of the machinery, the deep-well pump in the old well was replaced by an air lift. By means of the latter, the flow of water was increased from 185 to 630 gallons per minute—giving a combined capacity for the two wells of 1,250 gallons per minute.

The air for the wells is supplied by a type POC-2, oil-engine-driven compressor — the unit consisting of a horizontal, single-cylinder oil engine which is direct connected to a horizontal, single-cylinder, single-acting, 2-stage air compressor. The engine is of the 4-cycle, solid-injection, cold-wall pattern, and the compressor is of the differential-piston type with an intercooler below the cylinder. Each stage of compression is provided with a hand-operated clearance pocket which, when open, permits running the machine at one-half volume capacity without changing the speed. A 5-inch, single-stage, double-suction, Cameron centrifugal pump is driven by belt from the fly-wheel of the oil engine-compressor unit—the water being delivered into the surface reservoir by the air lift and repumped into the elevated tank or directly into the mains by means of the centrifugal pump. By operating the air compressor at half capacity, through the medium of the clearance pockets, this pump can handle all the water lifted and thus take care of the ordinary requirements.

For the sake of those interested in figures, the following air-compressor specifications are tabulated:

Dimensions of the air cylinder are 15½ and 12½x19 inches.

With both clearance pockets closed, at 100 pounds discharge pressure and 240 R.P.M., the air cylinder gives the following performances:

Piston displacement, cubic feet per minute	497.0
Cubic feet actually delivered per minute	408.0
Total indicated horse-power in the air cylinders	81.0
Brake horse-power at the compressor crank pin	89.5

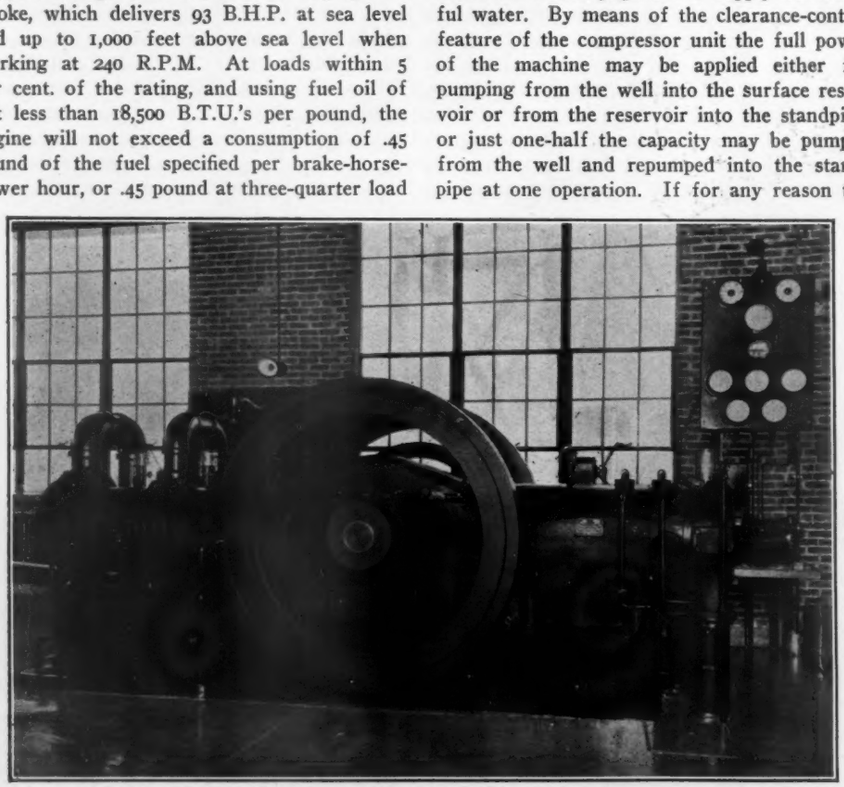
With both clearance pockets open the air cylinder performs as follows:

Piston displacement, cubic feet per minute	497.0
Cubic feet actually delivered per minute	204.0
Total indicated horse-power in the air cylinders	42.5
Brake horse-power at the compressor crank pin	51.5

Interior of water works at Elmhurst, Ill., with direct-connected generator, at left, driven by Price-Rathbun vertical oil engine, and type POC-2 air compressor at right.

The power end of the entire installation is a type PO engine, with 17-inch bore by 19-inch stroke, which delivers 93 B.H.P. at sea level and up to 1,000 feet above sea level when working at 240 R.P.M. At loads within 5 per cent. of the rating, and using fuel oil of not less than 18,500 B.T.U.'s per pound, the engine will not exceed a consumption of .45 pound of the fuel specified per brake-horse-power hour, or .45 pound at three-quarter load and .48 pound at half load. With the oil that is now burned, weighing 7½ pounds per gallon and costing 5½ cents, and with a consumption of 45 pounds per hour, the fuel cost when pumping at the rate of 630 gallons a minute amounts to 33 cents per hour or 87/100 cent per 1,000 gallons pumped from the well and delivered into the mains against the standpipe head of 43 pounds.

In order to provide electric current for driving the original air-lift plant in the basement of the City Hall, the new power plant includes a 3-cylinder, vertical, Price-Rathbun type PR oil engine, direct connected to an 80-KVA Westinghouse Ex-pole generator with belted exciter. On account of the very low fuel cost and the extreme flexibility of operation, all the facilities as they now stand represent an ideal equipment to supply the needful water. By means of the clearance-control feature of the compressor unit the full power of the machine may be applied either for pumping from the well into the surface reservoir or from the reservoir into the standpipe, or just one-half the capacity may be pumped from the well and repumped into the standpipe at one operation. If for any reason the compressor in the new power house should not be available for service, then electric current from the generator set may be resorted to to operate the compressor and the pumps of the original air-lift installation.



Ingersoll-Rand oil-engine-driven compressor installed at the City Water Works. This compressor furnishes air for operating air lifts by which water is raised from a number of the municipal wells.

The plans for this unusual pumping system were laid out by Mr. H. S. Crockett, a man of many years' experience in water-works practice and who was appointed City Superintendent of Elmhurst in the spring of 1920. Every engineering detail, both in the designing of the plant and in the installation of the machinery, has had his careful consideration; and to his resourcefulness is due the marked success of the undertaking.

MODERN OIL REFINERY AN INDUSTRIAL CITY

THE MODERN oil refinery is a city of stills, agitators, sweat houses, power plants, machine shops, plant railroads, unloading racks, storage tanks, etc., all underlaid by innumerable pipe lines bringing the crude oil, in some instances, from fields 1,500 miles distant. It is distinguishable from afar by rows of towering smoke stacks rising from batteries of pressure stills.

There are today in the United States over 400 refineries, ranging from the small plant, which "skims" or "tops" the oil, to the complete refinery yielding the entire array of petroleum products. They represent an investment of $1,500,000,000.

Gasoline is shipped from the refineries in tank cars to bulk distributing stations at central points. In all, there are 133,000 tank cars in the petroleum service, representing an investment of $266,000,000. From the distributing stations, gasoline is carried by motor truck to tanks at filling stations, garages, and roadside pumps, whence it finally reaches the consumer.

REFRIGERATING MINE AIR

REFRIGERATION of mine air to cool the working places, as successfully practiced at the deepest mine in the world, the St. John del Rey, in Brazil, could not easily be applied to most deep mines in the United States, according to Dr. T. T. Read, supervising mining engineer of the Bureau of Mines. Doctor Read says that in the mine where it is satisfactorily used the working places are filled as fast as the mineral is taken out, and the workings are quite dry. The principal effect of refrigeration is to dry the air and thus to reduce the wet-bulb temperature. In a wet mine, where the air could again take up moisture, most of the good effect would be lost before the air reached the working places. Further, in mines where the working places are larger in area the air currents have to be split, and, in passing along the hot wall, rocks at a low temperature would become heated. Fortunately, it is not so necessary to precool the air in this country as it is in Brazil. The average outside temperature of the air is lower, and in most cases it is possible to secure satisfactory conditions underground by circulating a large volume of ordinary air with fans.

The Chinese are gradually taking to wearing leather shoes or those that combine chrome-leather soles and native cloth uppers. One such sole outlasts three fabric tops.

Building the Queensboro Subway Extension

An Engineering Task of the First Magnitude Which is Being Pushed Forward With Marked Success Largely Because of Pneumatic Facilities Employed

By S. G. ROBERTS

"AN ENGINEERING problem of five major hazards."

In this brief way certain experts have summed up the momentous task involved in the construction of the Queensboro subway extension at 42nd Street, New York City. We might supplement this by saying that three of these hazards have already been skilfully met, and that the two remaining will undoubtedly be dealt with with equal success by those responsible for the undertaking.

Somebody has playfully described the Metropolis as the "greatest mining camp in the world;" but only a few of the 6,000,000 citizens of that teeming municipality realize how truly apt this characterization is. The physical limitations of Manhattan Island have compelled extensive tunneling and the digging of subways in order to furnish underground arteries for the transportation of hundreds of thousands of people during the rush hours of traffic of each week day. In turn, it has been necessary for their builders to pierce more or less protracted stretches of the island's rocky backbone, and to do this at varying depths below street levels and beneath the feet of a hastening and unheeding throng.

The total overall length of the present job is 3,660 feet; and because of the nature of the work, its magnitude, and its proximity to large structures—not to mention the fact that the new line will at points underrun other subways carrying heavily loaded trains—the project is one of the most difficult of its kind that has ever been essayed in New York City. Before entering upon the details of the undertaking, let us outline the route to be traversed and the reasons for the construction of this transportational link, which is designed to connect the Queensboro subway with the Broadway and the Seventh Avenue subways, traveling north and south, several long blocks to the westward.

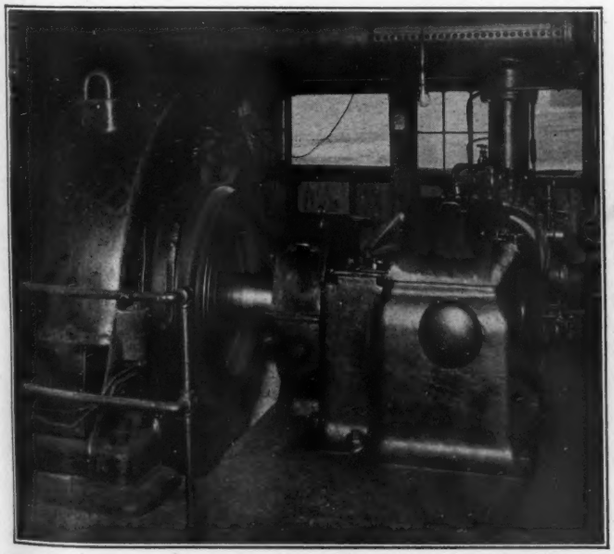
MORE and more must the engineer burrow through the bowels of Manhattan Island to open up amplified and widened routes for the daily transportation of a vast concourse of people bound to and from their places of business, the shops, the theaters, and other points essential to their diversified requirements.

The digging and the blasting of these underground traffic ways must be done with the least practicable disturbance of the accustomed surface movement of pedestrians and vehicles; and because of this imposed condition many tasks of this sort go on to completion with little if any knowledge on the part of the public.

The accompanying article describes the means employed and the progress already made in carrying out one of the most difficult subway projects yet taken in hand.

Starting at a point 74 feet below grade on 42nd Street, near Vanderbilt Avenue, twin tunnels have been driven on an ascending grade that merge into a single double-track tunnel just east of Fifth Avenue, and the latter tunnel joins an open-cut excavation, 60 feet west of Fifth Avenue, which extends along the north side of the great New York Public Library situated at Fifth Avenue and 42nd Street. The depth to rail base at the station to be located in this excavation will be 42 feet below grade. The open-cut work will turn to the south and cross adjacent Bryant Park until a short distance from flanking Sixth Avenue, where a tunnel running under 41st Street will continue the route to the west building line of Broadway and there link with an open-cut station excavation reaching from Broadway to the middle of the block between Seventh and Eighth Avenues. At Seventh Avenue rail base will lie 53 feet below the street level. On the west, this station will join a 2-track tunnel under 41st Street terminating just beyond the center line of Eighth Avenue. All told, the excavational work will entail the removal of 37,000 yards of earth and the drilling and blasting of 189,000 cubic yards of rock—most of it hard schist.

At the present time, passengers using the Queensboro subway reach the station at 42nd and Broadway by shuttle trains running over a section of the original west side sub-



Until recently this "Imperial" type XE-2 direct-connected compressor, with a capacity of 1,600 cubic feet of free air per minute, has furnished energy for the operating of all pneumatic equipment. A second machine, "Imperial" type 10, having an output of 660 cubic feet of air, has been added lately.

In the central blacksmith shop compressed air furnishes the blast for the forge and operating power for the "Leyner" drill sharpener. In the course of a shift the latter tool sharpens as many as 200 steels.

way and, in traveling east from Broadway to the Queensboro terminal, they go by the same route. The operation of these shuttle trains is not sufficient to prevent congestion at rush hours because of the enforced break in the journey. Therefore, the Queensboro extension is rightly regarded as an important improvement and one that will greatly ease the traffic movement. According to a recent count made by inspectors of the New York State Transit Commission, 100,000 persons are now carried daily by the shuttle, and fully 25,000 of these transfer to and from Queensboro trains. In other words, existing congestion will be reduced 25 per cent.; and when the new link is ready it will be possible for passengers to board a Queensboro train at Times Square and go thence eastward to the Grand Central station and onward without changing.

In the open cut beneath 41st Street near Seventh Avenue. Note the manner in which steel girders and timbering are utilized to carry the heavy decking which now forms the vehicular roadway.

The contract was signed April 21, 1922, and, according to the terms of that instrument, the Powers-Kennedy Contracting Corporation is called upon to complete and to deliver the subway extension to the city on or before April 29, 1926. The contract price is $3,867,138; and the builder has been required to furnish a bond to the city for faithful performance to the amount of $1,000,000—the largest sum yet imposed for such work. This, in itself, indicates the importance of the undertaking and the difficulties connected with its execution.

Up to date, the most exacting and the most dangerous part of the project has been the driving of the tunnels forming the extension between Vanderbilt Avenue and the open-cut excavation immediately north of the library. The twin, single-track tunnels have had to underrun a great sewer having an internal diameter of six feet, and the crown of the excavation for each of these tunnels has been only four feet below the bottom of the sewer. This conduit is always about two-thirds full; and had the drilling and the blasting ruptured it, a flood of 37,000 gallons a minute might have been set free to inundate the new tunnels and the associate Steinway tunnel.

When the tunneling neared the sewer, only short holes were drilled and these were spaced at close intervals—the holes having been previously drilled in the roof. By using light charges of dynamite it was practicable to dislodge with a minimum of shock small quantities of the rock, and thus to break the tunnels through without damaging the near-by sewer. Further, the concrete arch of the tunnel lining was put in place shortly afterwards so as to make doubly sure of leaving the sewer properly supported. Fortunately, the contractor encountered rock without seams in this stretch. So much for the first hazard.

Now for the second hazard, the driving of the twin single-track tunnels, each of which has called for an excavation 16½ feet wide and 17 feet high. The bench generally has had a depth of 20 feet from the face, and has been from 7 to 9 feet in height—the interval between the bench and the crown of the excavation being least when rising close to the overlying shuttle subway. This precaution has been necessary where the two tunnels come up directly beneath the old 42nd Street subway just before they swing to the south and join the double-track tunnel. In carrying on this work the roof of the north tunnel was advanced at a depth which would leave as much rock as practicable between the floor of the subway above and the bottom or pilot heading. The concrete arch of the completed tunnel was brought almost up to this depressed tunnel roof, after which line holes were driven along the roof, light charges fired, and the remainder of the roof excavation thus completed just in advance of the concreting. In this way, the contractor was able to restrict to a reasonable minimum the amount of finished but unsupported excavation. By holding to this procedure, the new tunnel was gradually driven upward to within only a few feet below the operating shuttle track; and so carefully was the drilling and blasting done that the superposed subway was unharmed and the second hazard met and overcome without mishap.

In driving the twin tunnels, an advance of from six to seven feet was made at every shot in each of them. A round consisted of 53 eight-foot holes drilled during an eight-hour shift by two No. 248 "Leyner" drills. The holes were started with steels having 2¼-inch bits and finished with 1⅝-inch bits—the variation being ⅛-inch with each change of steel. Four-point bits were used having tapers of 14 and 5 degrees. A matter of 65 "Leyner" steels were employed during a round, and 20 steels were utilized for the drilling of the bench.

The side walls, the arch, and other features of the tunnel lining are of concrete which is placed in its entirety by a pneumatic apparatus of the so-called gun pattern. This placer is operated by air at a pressure of 80 pounds to the square inch, and handles at each "shot" a batch one-sixth of a cubic yard in volume. Concrete has been thus delivered by the gu

Facing east from the shaft at Seventh Avenue and picturing the first lift in the rock in the open cut beneath 41st Street. This gives another view of the system of supports used in carrying essential piping and the overlaid traffic deck.

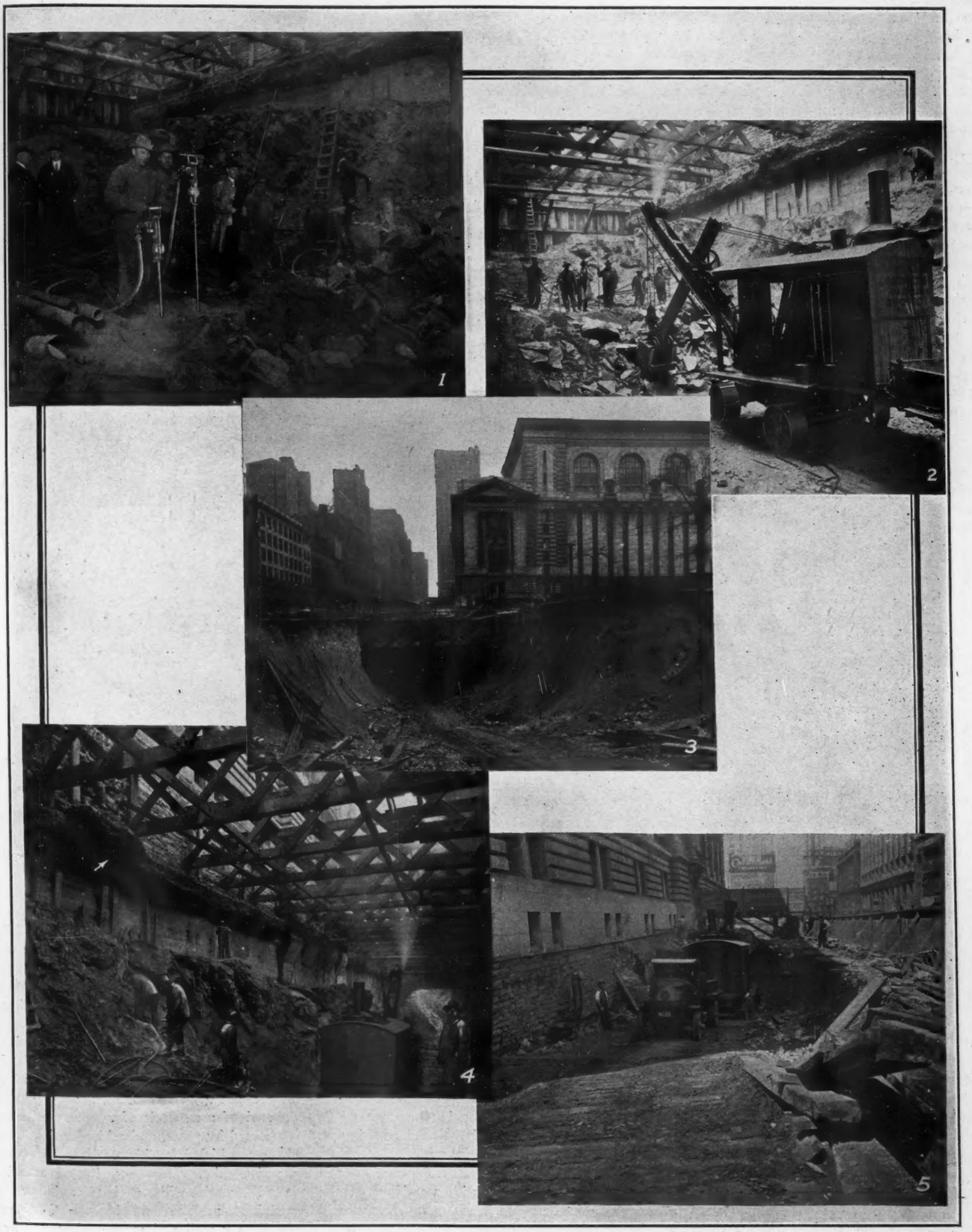


Fig. 1—"Jackhamers" have been the contractor's main reliance in drilling the rock in the open cut contiguous to the Public Library. The average lift drilled and blasted at each round has had a vertical depth of 15 feet. Fig. 2—A novelty in the field of subway excavation. This steam shovel has been remarkably efficient in handling and loading rock into the trucks. In the course of a single shift it has been able to deal with 410 tons. Fig. 3—The open cut north of the Public Library viewed from the ramp at the western end. The heavily laden motor trucks engaged in hauling rock out of the excavation are eased up the slope by a line from an air-operated hoisting engine. Fig. 4—The open cut immediately north of the Public Library. Arrow indicates under side of the library's original foundation. The space between this and the rock below, at points fully 25 feet, has been filled in with concrete underpinning. Fig. 5—An early stage in the excavating of the open cut alongside the Public Library. This view was taken looking west from Fifth Avenue, and shows some of the buildings flanking 42nd Street.

through a 6-inch pipe for a distance of fully 800 feet—making as many as nine 90° bends in its journey. In the course of half an hour, 42 batches have been placed by the apparatus. Perhaps it might be just as well to describe more fully the concreting outfit which has played a prime part in speeding up the work on the easterly section of the undertaking.

At the southwest corner of Park Avenue and 42nd Street, a small hopper, which is even with the curb, is connected with two pipes —one of four inches and one of nine inches in diameter. The larger conveys gravel and the smaller handles sand. The gravel falls by gravity through the 9-inch pipe into a bin built 70-odd feet below in the loop of the old Steinway tunnel, while the sand descends in a similar fashion through the 4-inch pipe and is deposited in an adjacent bin. The flow of the sand is stimulated by water which is drained off when the sand reaches the bin. Sand and gravel are shifted by hand to a single-bag batch mixer, below the discharge chute of which is set up the pneumatic concrete placer.

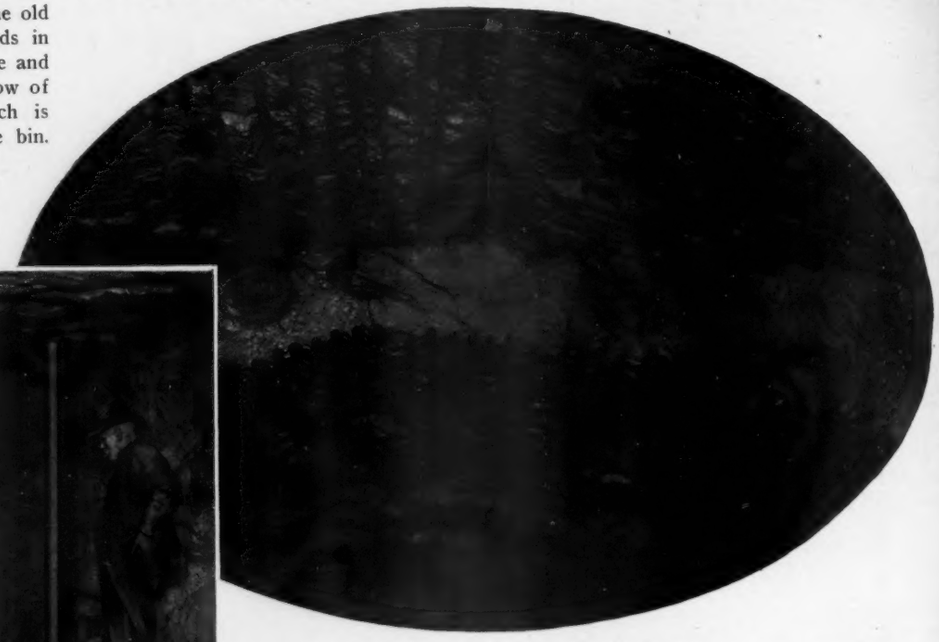
A heading in one of the twin tunnels under 42nd Street showing one of the eight No. 248 "Leyner" drills used by the Powers-Kennedy Contracting Corporation in driving through the hard schist encountered.

Experience has disclosed that the concrete arrives at its destination in an excellent condition, and we are authoritatively informed that the resulting masonry is of the best—being without flaw or surface imperfections. A single gang, with this machine, has been able to place daily an average of 60 cubic yards of concrete. In fact, an analysis of the cost of concreting shows a much lower figure per cubic yard than had been considered possible when making the preliminary estimates. All the concreting will be done in the same way.

The central power plant which supplies motive air is situated several blocks away on 42nd Street and near the East River. The plant was installed some years ago to serve other subway work then in hand, and upon completion of it was left idle until the Queensboro subway extension was started. The main compressor is a direct-connected, electrically driven machine of "Imperial" type, having a 22-inch low-pressure cylinder and a 14-inch high-pressure cylinder with a common stroke of 20 inches, and a capacity of 1,600 cubic feet of free air per minute. This air has been used to operate all the "Leyner" drills and the "Jackhamers"—a total of 30 pneumatic tools; to drive several Cameron pumps installed for drainage purposes; to work a hoisting engine serving as a booster in pulling loaded trucks up a steep climb from the open cut alongside the Public Library; and to function a "Leyner" sharpener which is set up in the blacksmith shop in Bryant Park. The latter machine, which is capable of handling 800 steels per diem, has served to sharpen daily both for the "Leyner" drills and the Jackhamers" anywhere from 150 to 200 steels in the course of an 8-hour shift. Recently, the pneumatic power plant has been added to by installing a second compressor capable of furnishing 660 cubic feet of free air per minute at a working pressure of 80 pounds. This machine is belt driven from an electric motor, and is of "Imperial" type 10. It has a 16-inch low-pressure and a 10-inch high-pressure cylinder, with a uniform stroke of 14 inches. The two compressors will be able to meet all demands from now on.

The third hazard which has been disposed of has consisted of excavating the open cut alongside the library and underpinning that structure at the same time. This imposing edifice was finished in 1911 at a cost of $9,000,000. Despite its monumental character, the foundation for the library was not carried down to bedrock. The problem of the present contractor was, therefore, to interpose a continuous concrete support from the underside of the footings of the north wall and to extend this underpinning right down to solid rock. One of our illustrations gives a fair idea of the nature of the work and the thoroughness with which it has been done. As a matter of fact, the north wall of the library is more rigidly upheld now than it was originally.

The bottom of the open cut lies considerably below the base line of the original footings of the wall, and much care has been exercised in extending the excavation below that level. A closely spaced row of line holes has been driven about six inches out from the library wall on the exterior limit of the subway cut; and when excavating and blasting are later undertaken adjacent to that structure the rock will break readily along these holes and do no injury to the building or the concrete underpinning. A distinctly novel feature in connection with the open cut has been the method employed by the contractor in bridging the excavation.



This picture iuustrates the way the drilling was done close to and immediately beneath the large trunk sewer so as not to wrack that conduit when blasting the rock.

The Fifth-Avenue-station site occupies the entire interval between the north wall of the library and the south wall of the old 42nd Street subway—now known as the shuttle. Instead of a network of rangers and bracers, supported by posts, and with sheeting exterior thereto, which has hitherto been the common practice, the contractor has spanned the broad trench with a heavy timber truss sustained at one end by the footings of the library wall and at the other end by the subway wall. This arrangement has left a clear space of 44 feet in which the excavators have been free to carry on their various tasks unhampered and unimpeded. Indeed, the bridging has permitted them to employ a

The south heading advancing east below 41st Street from shaft located between Sixth Avenue and Broadway.

large steam shovel, and this machine has picked up and loaded into 5-yard motor trucks in the course of a single shift as much as 410 cubic yards of rock. Two men helping the steam shovel and seven men operating "Jackhamer" drills have done all the excavational work; and progress in the open cut daily—between 8 a. m. and 4:30 p. m.—has averaged from eight to nine feet. The employment of so large a steam shovel marks a unique departure in this field of activity.

The two additional hazards, yet to be contended with, will call for penetration beneath and the underpinning of the Broadway and the Seventh Avenue subways where the Queensboro extension will underrun them along the line of 41st Street. In the meantime, the contractor is pushing ahead with his open-cut work and his tunneling elsewhere along this section of the job. Here, as adjacent to the library, he is utilizing bracing methods which leave him a maximum of free space while providing the necessary support for the traffic threading the thoroughfare.

The system depends fundamentally upon the use of 20-inch I-beams of sufficient length to completely span the first excavation, and these beams sustain sills and stringers upon which rest a double-plank decking. These I-beams have been placed at a predetermined elevation relatively to the street surface so that all posts and blocking are identical in length and interchangeable. No wedges or other small parts likely to become loose are employed, and the structure is exceptionally rigid. The side posts are trussed to form longitudinal grades which, besides strengthening the structure, prevent swaying or lateral movement. The I-beams are held up by posts standing upon the rock, and the diagonal struts are carried from the bottom of the beams to the foot of these posts, adding thus to the stiffness of the whole, while the entire arrangement leaves the bottom of the excavation free for the prosecution of all operations. As one expert has expressed it: "Among the pronounced things observable about this work is the absence of a large timber gang and piles of timber and bracing material. The work has been so planned and conducted as to reduce timbering to a minimum and practically eliminates the usual large timber gang."

The contractor is outspoken in his acknowledgment of what compressed air is doing towards advancing the work at a rapid pace. The general manager, Mr. John J. Kennedy, has declared: "We have been especially pleased with the low up-keep cost of our drills, both the "Leyners" and the "Jackhamers," which have certainly had to contend with very hard and difficult rock. These tools have clearly demonstrated, among other things, the wisdom of standardizing one's equipment, for the resultant gains in efficiency have been very marked."

In closing, it might be of interest to mention that the contractor has utilized as an operating base at the eastern end of the project the old Steinway tunnel and the shaft reaching upward from it to the surface at the southeast corner of Park Avenue and 42nd Street. This shaft serves for the removal of excavated material and for the delivery underground of cement, sand, gravel, etc., while the tunnel beneath forms a convenient pump chamber in which is installed a Cameron pump. In the same underground passage are located a magazine and general storage facilities. The loop and the shaft of the Steinway tunnel have proved decidedly helpful in the prosecution of the work, and have been measurable factors in attaining and in preserving that unusual degree of cleanliness and orderliness which are noticeable in and about this focal point of activity. Here, as elsewhere, the contractor has shown his resourcefulness in adapting himself to conditions.

The officers of the Powers-Kennedy Contracting Corporation are A. J. Powers, president, John J. Kennedy, treasurer and general manager; Albert Carr, chief engineer; and Henry L. Kennedy, general superintendent.

Colorado School of Mines graduates, numbering about 45, recently organized the Alumni Association of the Southwest. At the time of their meeting, the following officers were elected for the ensuing year: Colonel Louis R. Ball, 1900, consulting engineer, Pasadena, Cal., president; Ward Blackburn, 1908, Ingersoll-Rand Company branch manager, Los Angeles, Cal., vice-president; Harry M. Fiske, Ingersoll-Rand Company, also of Los Angeles, secretary-treasurer.

The objects of the Colorado School of Mines Alumni Association of the Southwest are: To help to maintain the present high standing of mines in the profession; to definitely put Los Angeles on the map as a municipality and a port for serving the mining industry; and to foster social and fraternal relations between members. The office of the secretary of the Association is 834 Higgins Building, Los Angeles, Cal.

The Bureau of Mines now has 80 different industrial motion-picture films, valued at nearly $200,000, to be loaned free by the Department of the Interior to technical societies, colleges, schools, churches, and commercial organizations. These films have been produced at small cost to the Government—practically the entire outlay having been borne by the industries represented. They show the various processes employed in the manufacture, transportation, etc., of a wide range of products; and are always received with interest while dispensing valuable information.

A good view of the timbering employed by the contractor to span the open cut on the north side of the Public Library. At the left can be seen the exposed wall of the present 42nd Street subway shuttle.

RAISING THE GRADE OF A BUSY STREET

AN UNUSUAL job of street raising is being carried out in San Francisco, Cal., where lower Market Street, a very busy thoroughfare, has settled 24 inches below the official grade. This work involves not only the elevating of the car tracks, the paving, the curbs, and the sidewalks, but it also necessitates lengthening the high-pressure and the Spring-Valley water hydrants the requisite two feet. Owing to the character of the undertaking and to the scene of the activities, the contractors have had to resort to methods and to equipment calculated to do the work in the shortest possible time, and, to that end, three portable compressors have been put on the job.

The four car tracks which traverse Market Street are being raised two at a time under the supervision of the Engineering Department of the Market Street Railway; and inasmuch as traffic along that thoroughfare is fairly heavy—cars running at 12-second intervals during rush hours—the work is done between 11.45 p m. and 5.45 a. m. In this way two tracks are always open to service at night when travel is lightest.

A special car is provided with a 3,000-pound drop hammer, and this is used to partly break up the asphalt paving and the concrete base. This hammer operates on the order of a pile-driver—it is raised by an electric motor on the car and permitted to strike the asphalt after a drop of about seven feet. Next come two crews equipped with special pneumatic paving breakers, and these so break up the concrete that the material can readily be shoveled into dump cars for disposal. The old rails and the ties are pulled out with a derrick crane; and the new ties are put in position and tamped with pneumatic tampers. Before 5.45 a. m. each day new rails are laid and connected up with the old tracks so that the regular passenger traffic can go on uninterruptedly.

Electric power for the compressors is obtained by tapping the trolley wires. All three of the machines are portable. For the sake of convenience, the large compressor, which supplies the operative air for the tie tampers, is left at the job during the daytime, while the two smaller portables, which furnish compressed air for the paving breakers, are taken away after each night's work. For the purpose of providing adequate light, three powerful electric lamps with suitable reflectors are suspended from each of the trolley poles.

Pneumatic paving breakers similar to the tool shown here were used on the Market Street job.

The Board of Public Works has charge of the raising of the street paving, the sidewalks, and the curbs, while the Fire Department is lengthening and elevating the hydrants. In this work, a burner, operated by compressed air, is used to melt away the lead between the joints of the high-pressure piping. This burner is attached to the end of a pipe, about six feet long, which is so bent that the operator can sit at the top of the excavation and burn out the lead.

Ever since the old waterfront line was pushed out into the bay, Market Street has been steadily settling and, finally, reached a grade that compelled action. The job of raising the street-car tracks will alone cost over $150,000. When all the work is completed, many of the old and small structures along Market Street which were left "high and dry" will actually be "low and wet," but the new and modern buildings, constructed on substantial piling, will stand, as they should, at the proper grade.

EASY TO WASTE GAS

IT IS as easy to waste gas, especially in cooking, as to burn it economically—in fact much easier. At the request of the American Gas Association, the Bureau of Standards has been conducting some interesting and valuable experiments looking to the cutting down of gas bills. The difference between the careful and the extravagant use of burning gas means a great difference in the bill at the end of the month.

When water boils, under kitchen conditions, it cannot get any hotter, and an attempt to hurry things up always means waste. The gas flame needed to heat cold water to the boiling point is generally much bigger than that required to continue the boiling. The following tests made by the Bureau are suggestive:

1—It was found that, with a lid on the utensil, violent boiling—gas turned on full—consumed about nine times as much gas as was needed to maintain gentle boiling. Violent boiling called for eighteen cubic feet of gas per hour, while gentle boiling required only two cubic feet with the same cooking effect.

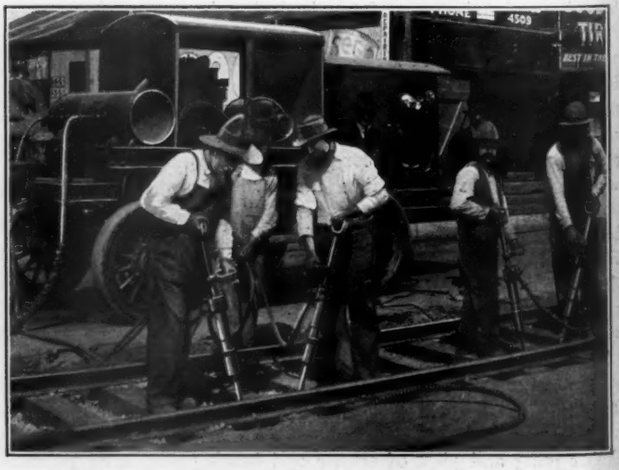
2—For gentle boiling, approximately five times as much gas was used with the lid off as with the lid on.

3—When violently boiled, water evaporated as quickly with the lid on as with the lid off, and consumed the same amount of gas.

4—Gentle boiling evaporated water about six times as fast with the lid off as with the lid on.

The Tanners' Council of America has authorized the appropriation of $110,000—the first cost of laboratory equipment necessary for the development and the improvement of the industry.

Oil under air pressure was delivered to a burner used in melting the lead calking in pipe joints. Man at left is burning a joint.



Air-driven tie tampers are now employed extensively in speeding up street-railway repair work like that in hand in San Francisco.

Pencils of Light and Photographic Films Give Talking Pictures

Phonofilm Weds Sound and Image and Starts the Art of the Movie Upon a Path of Wonderful Promise

BY LEE DE FOREST, PH.D

DOES THE public want talking pictures? I asked myself that question many times some years back; and the more I pondered it the more convinced I became that there was a demand, a well-defined field of usefulness, for such an innovation. It was apparent to me, at least, that the movies as we have them are lacking in a vital essential—at best they are nothing but artistic pantomime.

I was fully alive to the efforts of other workers who were bent upon the reproduction of speech or the voice in combination with animated pictures, and I was conscious of the difficulties to be encountered in bringing about a satisfactory union—among them that of synchronizing the voice with the visible action so that there would be no disturbing or marring lag.

Undismayed by the complexity of the task, I resolved, five years ago, to focus my labors upon devising a system that would produce talking pictures photographically. I was urged to this by the belief that I could thus find a new and useful application for the audion amplifier. I was convinced that it was possible to utilize a pencil of light instead of a steel needle for the reproduction of sound—in this way, avoid the limitations of the phonographic disk and sidestep contacts which would cause scratching or other objectionable sounds.

At the very start of my investigations I prescribed a number of conditions which would have to be satisfied, and these were based entirely upon commercial considerations. Probably it would be helpful to an understanding of my self-imposed task if I outline these specifications at this point:

1—Nothing but a standard cinematograph film could be employed.

"TALKING PICTURES" are the latest product of that versatile scientist, Dr. Lee De-Forest, who has done so much to advance wireless communication.

In this new field of research and service, Doctor De Forest has latterly achieved a notable measure of success, and, seemingly, he has laid a firm foundation for wonderful developments in this art just as he did when his genius for things electrical led him to evolve his epoch-making audion.

How he has met and solved some of the most difficult problems associated with "talking pictures," Doctor De Forest tells us in the accompanying article. Likewise, he gives us a hint of what this evolution of the "movies" may lead to in time—perhaps in the near future.

2—The speed must be that of the standard motion picture film.

3—The recording and the reproducing devices must be absolutely "inertialess," except, possibly, the diaphragm for receiving and the diaphragm for reproducing the sound.

4—The receiving device must be sufficiently sensitive to permit its being successfully concealed at a reasonable distance from the speaker or the source of music to be photographed.

5—The reproduction must be as good, if not better than the existing phonograph, and loud enough to fill any movie theater.

6—The photographic sound record must be so narrow as not materially to cut down the size of the normal picture projected on the screen.

7—The width or amplitude of the photographic record on the film must be constant throughout, and the sound variations must be registered as variations in the density of the photographic image. In other words, the light record should be in the form of exceedingly fine lines or parallel bands, all the same length, and lying transverse to the travel of the film.

Early in the spring of 1919 I filed patent applications on the methods which I believed would accomplish the aforesaid conditions, and began experiments with the various means which might be successfully employed. At that time, I figured that the task involved would require at most two years—a period one-half as long as that actually demanded. The work has gone on well-nigh uninterruptedly, and has been of the most exacting and discouraging nature: literally hundreds of tests have been made, and thousands of feet of film have been photographed only to be thrown away.

The "phonofilm," as I have called my invention, is a photographic record on the same reel of both pictures and associate sounds, and standard cinematograph film is employed. The sound record occupies a strip of the film, at one side of the picture, about 3/32 inch wide, and is so located that it does not materially reduce the width of the image. One of our illustrations shows part of a phonofilm.

Looking into the phonofilm projector. In the upper compartment are the photion lamp at the left and a highly sensitive photo-electric cell at the right. The latter transforms variations of light into electrical waves capable of reproducing sound waves. In the lower compartment is seen the film passing before the picture-projecting apparatus.

Doctor De Forest examining a photion bulb. The intensity of the light of this gas-filled lamp varies in strength with every fluctuation of the electric current passing through its filament. This current is affected by a telephonic receiver which responds to sound waves. Thus, by the cunning interrelation of light waves, sound waves, and electric waves, talking pictures are produced.

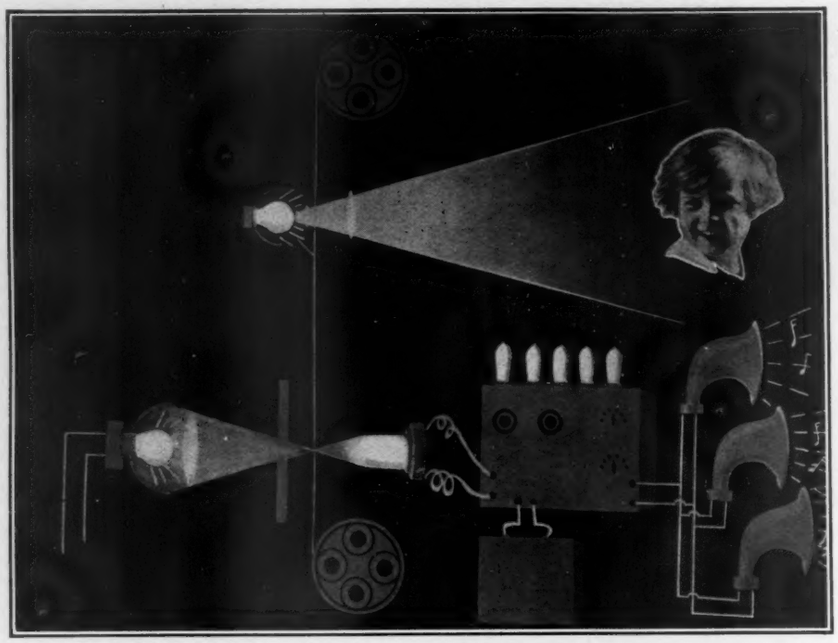


Chart illustrating the method employed in reproducing moving pictures and sound waves which have been registered on the same film. Two different parts of the film are used simultaneously during the reproducing function of the phonofilm projector. The success of the process hinges upon the use of a photo-electric cell. The photographic markings of the sound record control the amount of light thrown upon the photo-electric cell which, in its turn, changes light waves into electric vibrations that are afterwards amplified by means of audion lamps and loud speakers.

An especially designed gas-filled lamp, known as the "photion light" is inserted in the moving picture camera a short distance from the usual objective lens. The light from this photion tube passes through an extremely narrow slit and falls directly upon one margin of the film. This margin is screened from the picture itself so that only the light from the photion falls upon it. The film is driven continuously, with an even speed, in front of this narrow slit, but in front of the picture aperture the film passes with the usual intermittent step-by-step motion.

Now the light in the photion tube is generated by an electric current passing through the gas enclosed therein. The intensity of the light depends on the intensity of the electric current. Therefore, if a powerful telephonic current is passed through the photion, the light emitted at any moment varies exactly in accordance with the strength of the telephonic current. The brightness of this light therefore fluctuates hundreds of thousands of times a second in perfect rhythm with the telephonic-current pulses and varies in strength with the current.

The telephonic current originates, in the first place, from a special microphone transmitter, which is quite unlike the ordinary telephonic microphone but serves the same general purpose. This transmitter picks up the sound waves at distances of from five to fifteen feet and transforms these waves into very weak telephonic currents. An audion amplifier is then used to amplify these weak currents 100,000 times in order to make them strong enough to influence the photion lamp in the camera. Without the audion amplifier the whole scheme would be utterly impracticable because of the weakness of the voice currents. Thus we have three transformations: first, sound waves into electric telephonic currents; second, the amplification of these currents into light waves; and, third, the registration of these light waves through the narrow slit upon the photographic film.

The negative film which carries the picture and sound record is now developed in the usual manner; but a suitable developer is used to bring out the details of the sound registered. Positive prints are made by the aid of a special form of printer to give the necessary light values to the picture and to the sound record. This positive print is then run through a standard moving-picture projector. A small attachment is added to the machine, and this auxiliary includes a little incandescent lamp and a highly sensitive photo-electric cell—the latter the invention of T. W. Case. As the film travels through the projector machine it passes between the lamp and photo-electric cell. The light from the incandescent lamp is concentrated upon a tiny slit, similar to that already described, and then goes onward through the sound record which has been photographed on the film. After penetrating the interposed film, the light rays enter a chamber containing the photo-electric cell. The travel of the sound record across the narrow slit controls, accordingly, the intensity of the light falling upon the sensitive cell.

The photo-electric cell has this peculiar property—its electrical resistance at any instant is determined by the amount of light falling upon the cell. Therefore, as the film moves across the slit, the light falling upon the cell is made to fluctuate hundreds of thousands of times per second, and the electrical resistance of the cell is thereby varied in agreement. A small battery is connected with the photo-electric cell to supply current—the flow of the current being controlled by the light falling upon the cell. Thus it is possible to exactly reproduce the wave forms of the original telephonic current as they were generated when the sound picture was first recorded. As this new telephonic current is extremely weak it must be strengthened, and this is done by sending it through a series of especially designed audion amplifiers which multiply its power hundreds of thousands of times. This robust telephonic current is then passed through suitable loud reproducers which are located behind or alongside the moving picture screen so as to cause the sound seemingly to come from a person or any other source which may be shown upon the screen.

The phonofilm process solves the problem of synchronism. The photographs of the sound and of the associate object are always together on the same film and are invariably at the same relative positions.

Throughout my work I have aimed to make the process practical and of commercial value; and this has been achieved in large part by

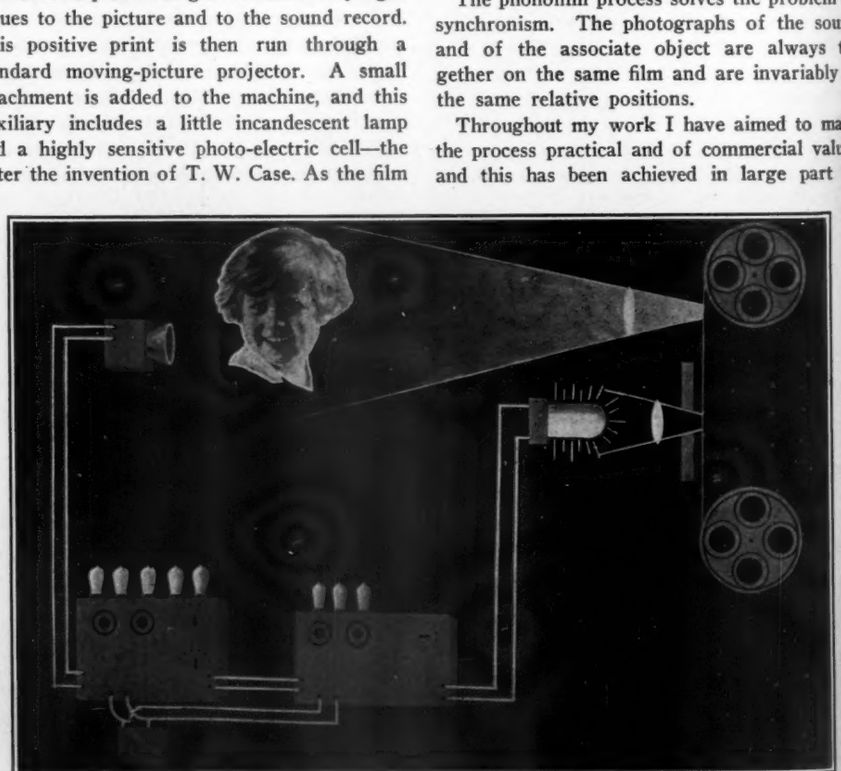
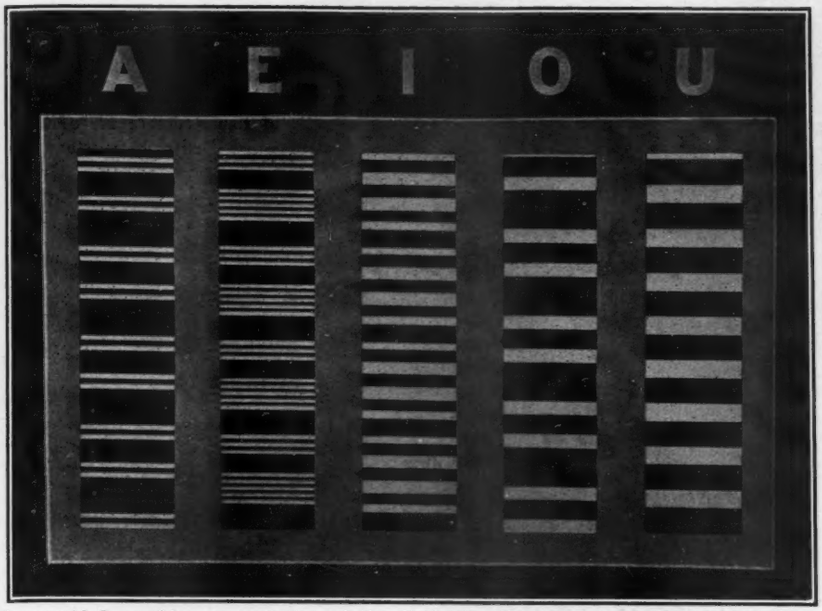


Diagram of essential elements by which moving pictures and sound waves are photographed on the same film. The sound waves are recorded as fine lines on a narrow path at one side of the regular movie images. Sound waves are picked up by telephone transmitters, then amplified to radio frequency, and thereby control the amount of light produced by the photion lamp. By this light, photographic records are made of the original sound vibrations.



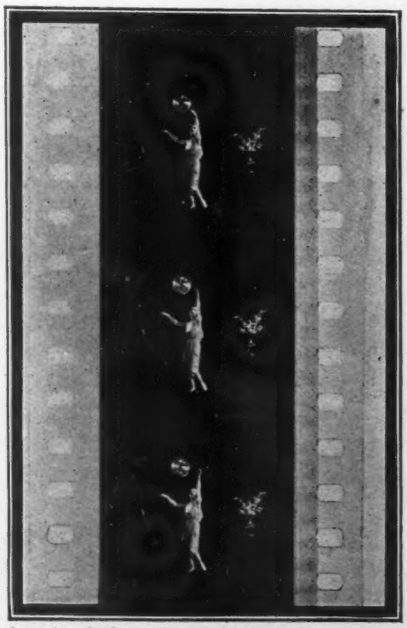
A magnified graphic representation of the distinctive lines registered photographically on a film when the five principal vowels of the alphabet are sounded before the phonofilm apparatus while acting as a recorder. All other sounds have their characteristic lines.

adapting my invention to existing standard apparatus. Accordingly, any motion-picture theater can be easily equipped for phonofilm productions.

Again, we are led to query: Is there room in the realm of the silent drama for screen versions which are not merely pantomime? Can the picture and the sound which go together so naturally in actual life be reunited artifically so as to give a pleasing and artistic effect? These questions cannot be answered offhand. Let us explain. When the moving picture was first evolved the idea prevailed that movie plays would be nothing more than photographic reproductions of familiar stage performances, with certain limitations as to the scope of the scenes, the number of the characters, etc. But it did not take long to demonstrate the inability of the movie to enter into successful competition with the accepted order of drama. Something entirely novel had to be devised in order to make screen versions what they are artistically today.

The situation, therefore, as far as the future of the phonofilm is concerned, is much like that which first confronted the silent-picture industry; and talking movies must not seek to follow blindly in the path of the legitimate stage. The phonofilm must take full advantage of the immensely wider ranges which are inherently its own and enter new fields which are closed to the older form of pictures and order of entertainments. It seems to me that a radically different kind of screen play can be worked out, taking advantage of the possibility of introducing music and the voice. These innovations will not have to continue throughout the entire action, but be brought in here and there whenever they may add to the theatrical effect—something that is unattainable with pantomime alone, no matter how cleverly the latter may be worked out.

Finally, talking pictures will enable us to perpetuate the acts and the words of persons who are consciously or unconsciously making history, or who are significant characters in the public eye for one reason or another. Could we now see and hear Lincoln delivering his immortal address at Gettysburg, what an inspiration that would be to us! Just think what our pleasure would be if Edwin Booth as Hamlet, Henry Irving as Richelieu, and Mary Anderson as Juliet might be made visible and vocal for us and for those who shall come after us! Talking pictures will fill this gap and give to our children and children's children this boon which has been denied us heretofore. I leave to your imagination the other ways, so many of them, in which this wedding of electricity and light for the reproduction of sound and image will serve to entertain, to enlighten, and to keep alive for ages to come the things that now appeal to the eye and to the ear.



A strip of phonofilm made during an exhibition dance which was accompanied by an orchestra. The narrow, lighter band at the right of the movie picture is the photographic record of the music.

MECHANICAL MUCKERS SPEED TUNNEL WORK

THE NORTH JERSEY District Water Supply Commission has now in hand a project which will link the reservoir at Wanaque with the reservoir at Belleville, separated a distance of twenty miles. Part of this undertaking involves the driving of what is known as the Great Notch Tunnel through the rocky backbone of Watchung Mountain for a stretch of 9,100 feet. As a matter of fact, the plan may be so altered before the job is done as to increase the length of the tunnel by 200 feet. At its greatest depth, the line of the tunnel lies 300 feet below the surface. Despite this, there is no intention to sink shafts at any point but to work inward from two portals toward a common objective where the headings will meet.

The finished section of the tunnel will be horseshoe shaped, having a height of seven feet and a width of seven feet—the invert having a radius of seven feet. The tunnel is to be lined with concrete, and the maximum rock excavation averages nine feet in height and the same dimension in width. Owing to the size of the tunnel, an entire heading is blasted at a time, that is to say, a drill round consists of twenty holes driven by three "Leyner" Ingersoll drills. The holes are charged with six pounds of 60 per cent. powder per cubic yard. The drilling is done in two shifts, firing taking place at the end of each shift, after which the mucking is performed.

Heyman & Goodman, of Jersey City, are the contractors for the tunnel, and they are employing three Hoar mechanical shovels for mucking. These machines are doing their work well notwithstanding the limited space in which they have to operate. Each mucker is equipped with a bucket arm and bucket, which can be slid forward and downward until the bucket rests upon the ground at the foot of the muck pile. Then, by pulling on the upper end of the arm, which is pivoted near the center, the bucket is forced into the muck pile. When filled, the bucket is raised and the arm moved into a horizontal position until it lies on top of the car. The car can be swung through a complete circle on a supporting turntable, and, by reason of this arrangement, the bucket can be brought over a mucking car at either side of the shovel or in the rear of the machine. However, because of the comparatively restricted space available, side loading is not practicable, and the contractor has, therefore, placed a portable conveyer at the rear of each shovel, and this conveyer delivers the muck into 3-yard narrow-gage cars which can be spotted under the carriage of the conveyer.

Compressed air for the mechanical shovels and for the driving of the drills, etc., is supplied by a plant near each portal of the tunnel. The prime mover at each of these power stations is a 165-H.P. semi-Diesel engine. The compressors are "Imperial" type 10 machines.

Under normal conditions, 200 pounds of powdered coal, or equivalent fuel, must be burned to produce a barrel of 376 pounds of cement. A 1,000-barrel kiln consumes approximately 60 tons of coal in 24 hours.

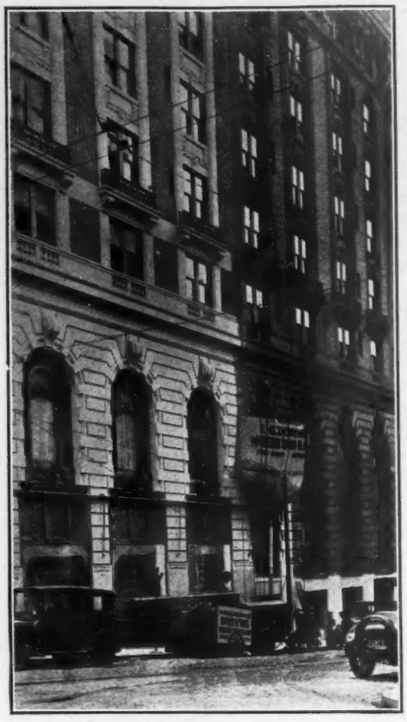
Putting a New and Bright Face On Things

THIS IS not the story of a beauty parlor but a practical account of what compressed air is doing in changing the dingy fronts of buildings.

Soap and water are the mediums most women rely upon in removing dirt about the household, but here is an exception to the rule: one who utilizes compressed air and sand to change the grimy face of things. Instead of floors and "sich like," Mrs. Edith G. Dobyns, of Cincinnati, Ohio, attacks the expansive facades of hotels and kindred structures; and as somebody has aptly expressed it, "No building is too high: nothing too difficult for her to undertake in her chosen field of endeavor."

To the world at large, Mrs. Dobyns hides her identity behind that of the Modern Sand Blast Company, but just the same she is the inspiration and the active head of that organization which has made a name for itself during the last few years in the Queen City and its environs. For a long while, Cincinnati has run a close second to Pittsburgh in the matter of a soot-laden atmosphere, which has left its disfiguring marks wherever a surface was exposed to the sweep of soft-coal smoke. As might be expected, the vagrant grime has given to many imposing edifices a drab, yes, neglected complexion. This was disquieting to Mrs. Dobyns' eye for cleanliness, and she decided that exterior house cleaning offered her an opportunity to do a public service and to realize a profit the while.

Accordingly, she set about incorporating herself under the title already mentioned, and proceeded to acquire a suitable sand-blasting outfit —the prime feature of this equipment consisting of an 8x8-inch Type 14, engine-driven, portable compressor. In addition to this were purchased numerous lengths of hose, a suitable array of sand-blast nozzles, together with special protecting helmets, etc., for the operators. Thus armed, Mrs. Dobyns announced her readiness to change the architectural aspect of Cincinnati, and since then she has made good in many directions. People that had come to look upon the begrimed, weather-stained fronts as inevitable, are now pleased that sand blasting can so effectively do away with these blemishes and give to buildings the charm and color of newness and freshness.



The Hotel Sinton, Cincinnati, Ohio, while having its facade cleaned by sand blast. Note difference before and after cleaning.

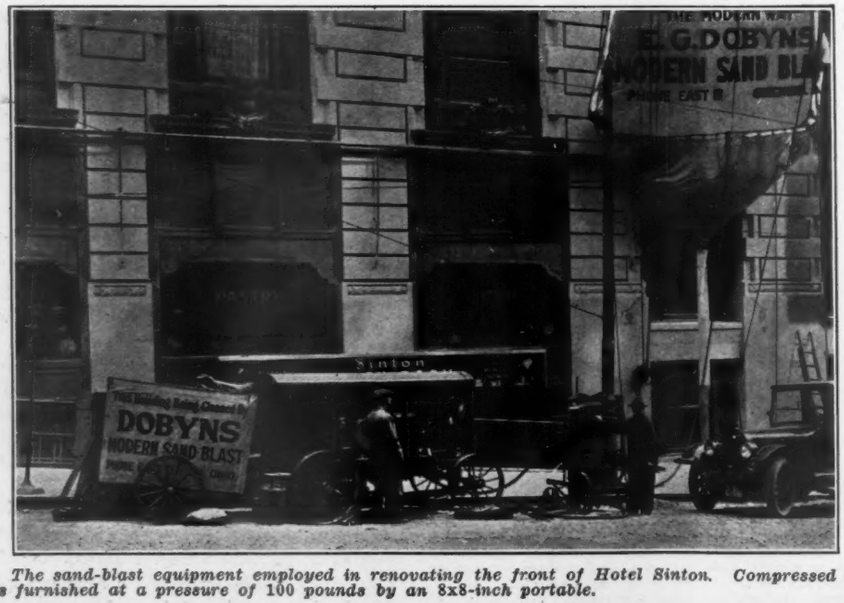
One of the latest structures so refurbished in the Queen City is the Hotel Sinton. The curtain walls of this structure are of brick while the finish is of Bedford freestone, which is used extensively throughout the Ohio region. One of the pictures with this article shows clearly the contrast between the sand blasted and the untreated areas—the effect is as if the sun were shining on one portion while the neighboring expanse were in the shadow of a cloud.

The Ingersoll-Rand compressor employed is capable of maintaining an air pressure of 100 pounds, but this was not needed in dealing with the brick and freestone. Generally, the pressure required did not exceed 60 pounds to the square inch, but in order to speed up the work somewhat this was raised to 80 pounds and ¼-inch sand-blast nozzles were used. Due to the rapid wear of the sand, it was found necessary to change the nozzles and to substitute new ones every 15 or 30 minutes, depending upon the activity with which the cleaning was carried on.

In dealing with freestone, Mrs. Dobyns' men had recourse to a fine, hard silica sand; and during the blasting about 25 per cent. of the sand was blown away or otherwise rendered worthless when the grains became broken up and reduced in size to the equivalent of dust particles. The 75 per cent. remaining was caught in the canvas screen or covering surrounding the scaffolding and carried back to the sand-blast tank on the ground floor, where much of it was made ready for further service by proper sifting. From four to five tons of sand a week were required on the job, and the gang was able to clean one tier a day. By tier is meant the width of the scaffold throughout a section extending from the ground to the eaves of the building.

The size of the air compressor used on the job was somewhat larger than necessary when feeding but a single nozzle; but on other work, where the desire is to hasten matters, it is practicable to operate two nozzles simultaneously while supplying them with air at a lower pressure. The character of the surface to be cleaned determines whether it is better to employ a single nozzle with higher air pressure or two nozzles with lower pressure. The gasoline consumption of the compressor engine averaged fifteen gallons during an 8-hour day.

We are indebted to the Kring-Becker Engineering Company, a well-known Cincinnati concern representing a number of big machinery manufacturers, for most of the information in this article, and this firm states: "The compressor outfit used in connection with the sand blasting of the Hotel Sinton has been in constant service since February of 1922 on various similar jobs throughout the city. During this period the machine has required no repairs other than new radiator tubes which were damaged in transit. This showing is remarkable when the fact is considered that the equipment while in action is continually exposed to clouds of fine, sharp silica dust which falls from the operator's scaffold."



The sand-blast equipment employed in renovating the front of Hotel Sinton. Compressed air was furnished at a pressure of 100 pounds by an 8x8-inch portable.

Mrs. Dobyns' company has been actively engaged in the sand-blasting business for the past four years, and has handled contracts both in and outside of Cincinnati. With her mobile plant she has successfully cleaned many kinds of stonework, has removed paint from brickwork, structural steel, etc., and has renovated terra cotta, tiling, stucco, and roofing of various sorts.

© Ewing Galloway.

A close-up of a hooded sand blaster high aloft on the face of a building.

PROGRESS IN PRODUCTION OF SYNTHETIC AMMONIA

By C. MORAN

THE EYES of the world of industrial chemistry are now riveted on a small band of workers in one of Uncle Sam's laboratories at Washington. There, in the Fixed Nitrogen Research Laboratory of the Department of Agriculture, under the direction of able chemists and engineers, ammonia is being daily recovered from what is practically waste material.

The big problem that is being solved is the recovery of ammonia from hydrogen and nitrogen with a minimum of effort and of expense as compared with the higher cost of producing ammonia by by-product coke ovens. The task of designing and of developing apparatus capable of operating at very much higher pressures than are now regarded commercially feasible is quite beyond the range of present engineering experience; but satisfactory progress has been made in the laboratory in this direction and further important developments are in prospect. An experimental compressor has been devised and put in actual use which is developing pressures up to 15,000 pounds per square inch. It is expected that the research work, when completed, will furnish the data necessary for the installation and the operation of small ammonia plants that might find a ready field of usefulness throughout the country.

The direct synthetic-ammonia process for the fixation of atmospheric nitrogen is the newest of the three processes which have been brought to a commercial stage, and at present offers the greatest opportunity for further development. In this process, a purified mixture of nitrogen and hydrogen is subjected to a very high pressure and brought in contact with a suitable catalyst, which is maintained at about 932° F. Under those conditions, nitrogen and hydrogen combine chemically to form ammonia in quantities of from 5 to 15 per cent. of the gases present—the percentage depending on the catalyst and the operating conditions. The ammonia so formed is removed, and the uncombined gases are returned to the apparatus and again treated.

Through the use of a high-pressure compressor and associate apparatus, capable of withstanding unusually high pressures and temperatures, a higher percentage of the gases is converted into ammonia, thus reducing to a minimum the amount of uncombined gases. Another feature is the extraction of practically all the ammonia from the gas mixture, after its passage through the catalyst, without introducing impurities in the gases which are harmful to the catalyst. In coöperation with the Bureau of Soils, a promising method of doing this has been developed, and involves scrubbing the gas under high pressure with a relatively concentrated solution of ammonia; recovering the ammonia thus extracted by releasing the pressure on the solution; and liquefying the liberated gas by compression.

The catalyst for effecting the union of nitrogen and hydrogen is, in a sense, the heart of the direct synthetic-ammonia process, as its efficiency in general is greatly reduced by even exceedingly small quantities of impurities in the gas mixture coming in contact with it. A satisfactory ammonia catalyst has been devised by the laboratory experts, who have also perfected a method for its manufacture on a large scale.

The production of hydrogen of required purity represents the principal expense of the entire process—the cost of nitrogen being relatively small. The recovery of hydrogen from various commercial sources has been and is being studied—special attention being given to the utilization of the hydrogen that now goes to waste in connection with the electrolytic manufacture of bleaching materials, caustic alkali, and oxygen. The quantity of hydrogen thus sacrificed is estimated at from 20,000 to 100,000 cubic feet daily at the different plants. Improvements have also been made in purifying the gas.

Estimates of the Fixed Nitrogen Research Laboratory indicate that a plant, capable of converting daily approximately 100,000 cubic feet of hydrogen into 2,000 pounds of ammonia, can be constructed at the source of this waste, complete in every respect and ready for operation, at a cost of $50,000. In such a plant, ammonia could be produced at from six to seven cents per pound. These estimates do not include the cost of procuring the hydrogen, and do not allow for royalties, but they do take into account operating materials, labor, repairs, and maintenance (2 per cent. on buildings and 15 per cent. on equipment). Besides, there are added 10 per cent. of the foregoing figures for contingencies, and fixed charges of 12½ per cent. on buildings and 20 per cent. on equipment.

The problem of the fixation of nitrogen is one of outstanding national importance both in war and in peace, inasmuch as nitrogen forms an essential constituent of explosives, fertilizers, dyestuffs, and many other substances used in the arts. The dependence of the United States on foreign sources for its supply of nitrogen compounds, particularly for

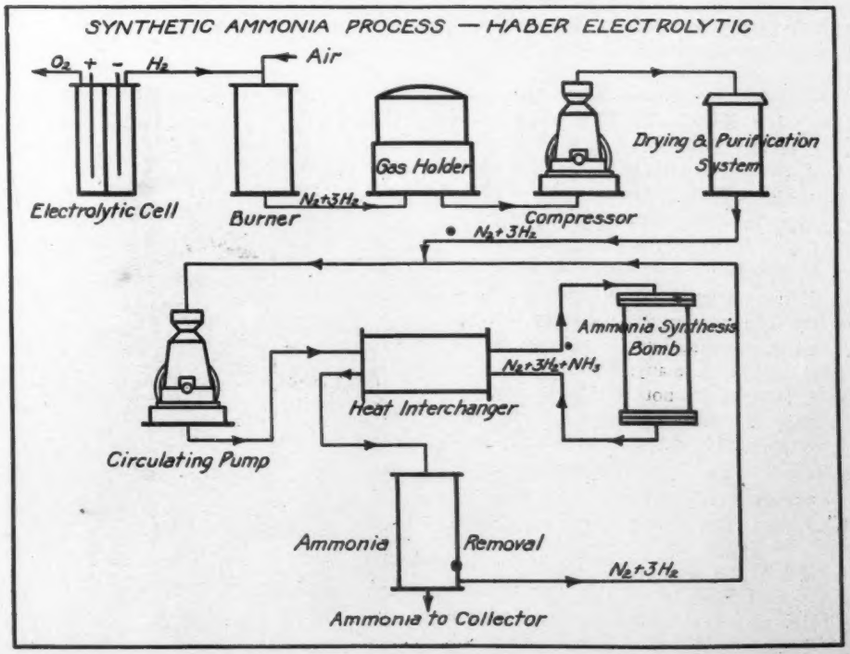
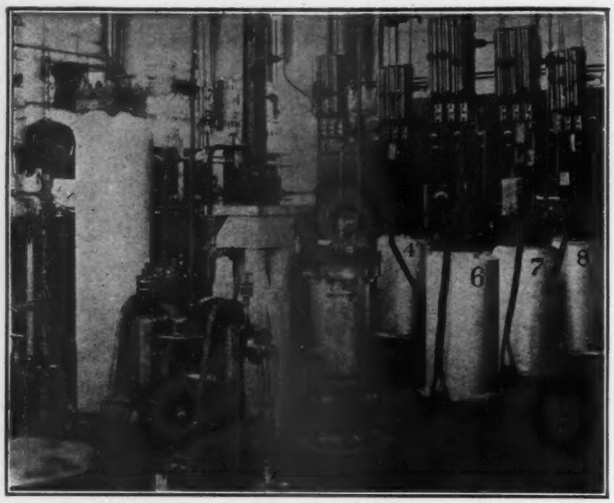


Diagram of the essential features, and their relation to one another, in plant for the synthetic production of ammonia.



General view of ammonia-removal equipment with catalyst testing bombs in the background.

the manufacture of explosives, was forcibly brought out during the World War, and the danger in such a policy became clearly evident.

While attempts were made to meet the immediate requirements by the importation of nitrates from Chile and by stimulating domestic production principally of by-product coke-oven ammonia, the necessity of conducting experiments looking toward the fixation of atmospheric nitrogen was readily appreciated and led to the establishment by the War Department, in 1919, of the Fixed Nitrogen Research Laboratory. The laboratory was subsequently placed under the administration of the United States Department of Agriculture.

According to Dr. Richard C. Tolman, former director of the laboratory, the study of the synthesis of ammonia from nitrogen and hydrogen is one of the most important lines of investigation being undertaken there. "The marked success achieved during the past few years in Germany in applying this reaction to large-scale nitrogen fixation, together with the important attempts which have been made in this country and in France, Italy, and England to utilize the same reaction, has emphasized the need of a broadly conceived study of the entire subject.

"The problem of economical large-scale ammonia synthesis is one of the most complex known to the chemical industry. It is capable of attack from a great variety of angles, and successful solution is perhaps possible under a wide variety of conditions. Thus, the method developed in Germany, largely as a war measure, is certainly not ideal and may not represent in any way the most satisfactory ultimate solution. The Fixed Nitrogen Research Laboratory is, therefore, studying the problem of ammonia synthesis from a broad viewpoint."

ATTACKING THE RATS' RESIDENCES

IN THE matter of rat extermination, the United States Department of Agriculture suggests the following method for the railroads: Fasten a length of hose to the end of the exhaust from a gasoline engine, whether it be that of a flivver or a tractor. Back the car up within reach of the rat burrow and adjust the carbureter for a rich mixture. Pack damp earth around the hose at the entrance to the hole so as to seat it. Run the engine at a moderate speed for ten minutes or more, and the rats will be destroyed. This method is entirely practical anywhere where there are but a small number of holes, or where the area to be fumigated is not too extensive.

TAKING MOISTURE FROM THE AIR TO MAKE TABLETS

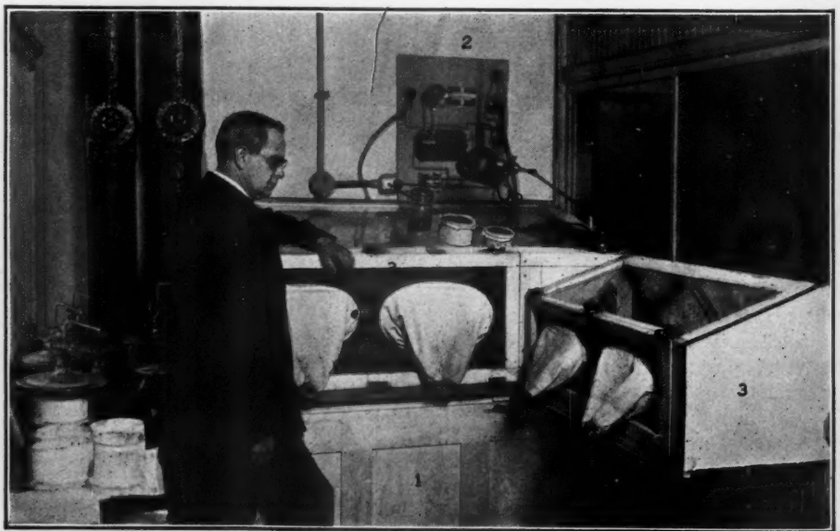
IN THE manufacture of tablets used in the ophthalmic test to detect tuberculosis in cattle, trouble was experienced because of the ease with which the material utilized took up moisture from the air. When the atmosphere was humid, the substance would become pasty and would stick to the knives and molds—rendering it impossible to shape the tablets. This hygroscopic tendency was so marked in the early stages of the work that the tablets could be compounded only when atmospheric conditions were just right—and in practice this happened on but 28 or 30 days out of the year.

This state of affairs imposed too great a handicap: it did not permit the making of the tablets in sufficient quantities to meet the demand. In view of the fact that the ophthalmic test has become very important in the fight against tuberculosis in cattle, this obstacle had to be overcome. Investigations were, therefore, started looking toward a method for regulating the humidity of the air; and an apparatus for this purpose has since been devised by John T. Bowen, of the Bureau of Animal Industry.

By means of the equipment, the relative humidity can be reduced to the point desired which, in this case, ranges from 30 to 35 per cent. By relative humidity is meant the ratio of the moisture actually contained in the atmosphere at a given temperature to the total amount of moisture that the air can hold at that temperature. When the atmosphere is hot it can absorb more moisture than when it is cooler. Ordinary heating or cooling affects the relative humidity as well as the temperature, hence the need for something that would regulate the moisture in the air and maintain it at the right degree. If the air is too moist, the tablets will become hard and will not dissolve readily when administered; but, on the other hand, if it is too dry the tablets will crumble.

The process for regulating the humidity has proved a great blessing, for it permits the work to go on the year through and thus to supply the several million tablets needed annually. Furthermore, it will find a ready field of usefulness for the preparation of a variety of tablets for other purposes. The method of manufacture is, briefly, as follows. Air, circulating in a specially constructed closed chamber, is cooled and dried by allowing it to pass repeatedly over brine and over electric heating coils, which latter raise it to the right temperature—the moisture content remaining the same. The air then flows into a box where the tablets are formed. This working chamber, devised by P. W. LeDuc—also of the Bureau of Animal Industry, is arranged to admit the hands of the operator without opening it to the outside air.

The temperature within the working chamber is maintained at the desired degree by a thermostat. In order to reduce the wear on the electrical equipment, the air is partly heated by two permanently connected heating coils while two other coils, which are adjustable, are used to regulate the temperature. These adjustable coils are controlled by the thermostat. By this arrangement, the thermostat is not taxed and can readily take care of the required temperature changes.



Apparatus for the control of atmospheric conditions during the manufacture of medicinal tablets. 1—Coil box for refrigerating pipes; 2—Electric temperature-controlling equipment; 3—Working compartments where tablets are made.

The Great Broken Hill Mines in Australia

Practice Followed in Working the Famous Deposits of Silver, Lead, and Zinc

PART II

By H. H. CARROLL and P. H. WARREN

IN THE PRECEDING issue, the authors described the geological nature of the Broken Hill mines, the character of the ores, and touched to some extent upon the practices adopted to reach the ore bodies and to get to the surface the metals found in those famous deposits. The present and concluding section of this story goes somewhat further into the means employed in exploiting these properties and also deals with the precautions taken to safeguard the personnel against underground menaces to health.

The practice of filling the stopes is now in general use in the field. Mullock, that is, muck, broken in developmental openings, is disposed of in this way, but the quantity so obtained is relatively small. Much of the needful mullock has been quarried and sent below ground, but the chief source of supply is the valueless residue from the concentrating mills that contains 2 per cent. lead, 1.9 per cent zinc, and 1.7 ounces of silver. The residue is appreciably moist when sent underground and, in course of time, sets firmly.

Wherever conditions justify the expense, the tailings are conveyed mechanically by belt. In the case of one large mine, the filling from the mullock passages to the stope winzes is so handled that distribution is effected in the stopes by means of laborers using trucks.

The cost of handling filling from the surface to the stopes is about 6 shillings per cubic yard or 1 shilling 6 pence per ton of ore extracted.

The ore broken in the stopes is thrown into chutes by the miners or fillers. From the chutes on the levels it is carried in trucks to the hauling shafts, and thence to the surface. Hand trucking, with 15-cubic-foot capacity trucks holding approximately one ton of ore, is the general practice in most of the mines, although animal transport is resorted to in some of them. Haulage by electric trolley locomotives was tried in the latter mines, but this was discarded in favor of draft animals. The tracks in the different mines are not standardized, and the gage varies from fifteen to eighteen inches. The trucking is usually done by contract at so much per ton. The method of letting the contracts varies—some mines prefer separate contracts, while in others the truckers are included in the stoping parties.

Both cage and skip hoisting are employed throughout the field, and the skips are constructed to carry about 2½ tons. In the main winding shafts the cages used are single deck, holding two 1-ton trucks. This is the general practice in all the mines due to the present contract system. The ore removed is paid for per ton; and in the case of skip haulage this necessitates the installation of weighing stations at each level.

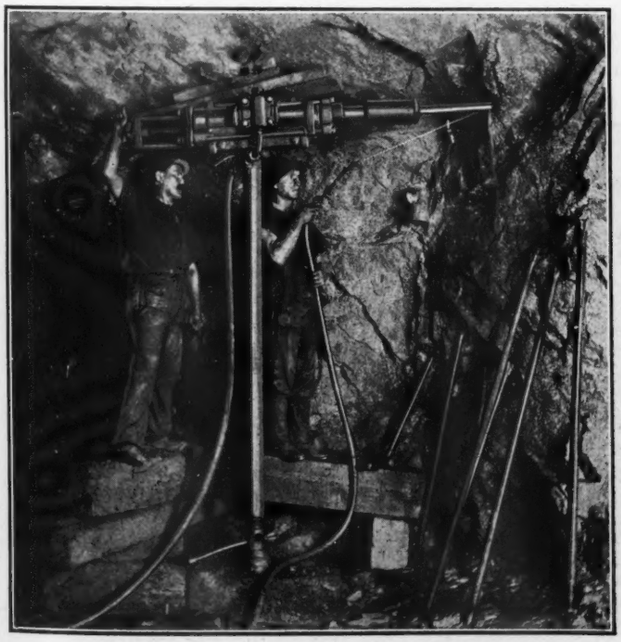
Air, steam, and electric hoisting engines are utilized, but the bulk of the winding is done by first motion steam engines. The air and the electrical engines are employed in the subsidiary hauling shafts.

In the matter of pneumatic drilling equipment, no standard type of rock drill has been adopted in the district, and at present both hammer and reciprocating drills are used extensively. The latter are, however, being gradually replaced by the more modern high-speed hammer drill; and the indications are that it is but a matter of time before the reciprocating drill will be discarded. As all rock drilling calls for water to prevent the formation of dust, the hammer drills introduced are of the wet-head type, or of a model that delivers the water at the cutting edge of the bit.

For stoping in the large, open stopes and for driving where continuous service is demanded, very satisfactory results have been obtained with the "Leyner" drill No. 248, and with the Sullivan DX61. Holman CH2 drills are also employed for this work and have given satisfaction. Where rock drilling is not continuous, as in square-set stopes, the "Jackhamer" type of rock drill has been found to be most useful. For still lighter duty—"popping" and cutting hitches for timber, etc.—small model "Jackhamers" have been adopted.

The steel used with the hammer drill has not been standardized either as to size or to composition. Generally speaking, the work so far done in this direction indicates that a steel with a carbon content of about .8 per cent and a manganese content of from .3 to .4 per cent. is the most satisfactory. The sizes of the steels vary in the different mines, and for the light type of hammer drill range from ⅞-inch to 1-inch hollow, hexagon, while for the heavier type it appears to be the practice to use 1¼-inch round, hollow steel.

Practically all the mines are mechanically ventilated with exhaust fans. In addition to the main fans, small, portable ones for ven-



Ingersoll-Rand piston drill boring holes in the face of a stll floor stope.

In large open stopes "Leyner" drills have been used to advantage in the Broken Hill district where continuous service has been demanded.

"Jackhamer" rock drills, of the type shown in this picture, are very useful in the Broken Hill mines in working in square-set stopes.

tilating dead ends have been generally introduced. During recent years this phase of mine hygiene has had serious consideration in view of the work done in connection with the study of occupational diseases—particularly those caused by the inhalation of dust. It is commonly recognized that good ventilation, accompanied by a judicious use of water, is the most effective means yet adopted to minimize the dust evil.

Special rules which form a part of the Mines Inspection Act, and are framed for the purpose of preventing persons employed in a mine from creating excessive quantities of dust, have been issued by the Mines Department from time to time. They may be summarized as follows:

1—All rock drilling must be accompanied by the use of water.

2—All broken material handled must be thoroughly wetted and kept wet.

3—Firing of explosives other than at the end of the shift must be restricted and controlled.

4—If firing is conducted other than as aforesaid, a permit must be obtained, and an interval of time must elapse before the men return to work.

To note the improvements brought about as a result of this effort to combat the dust evil, the Mines Department takes dust samples and makes temperature surveys periodically. Some of the mines have their own organizations for carrying out this work. Konimetric and gravimetric means of dust sampling are employed; and temperature surveys include Kata thermometer and wet and dry-bulb thermometer readings.

Underground workers in the Broken Hill mines enjoy conditions, both as to working hours and rates of wages, that are probably the best in the world. The award under which the mines are working was made by a tribunal appointed by the Government, pending the results of an examination of the mines and mine workers by a technical commission, and provides for a working week of 35 hours—5 days of 7 hours each—and a minimum wage rate of 18 shillings per day for unskilled labor.

The technical commission was appointed at the joint request of the mine owners and workers to investigate and to report upon the alleged high death rate caused by pulmonary diseases and lead poisoning. While the report did not support the claims of the miners, no relief has yet been obtained from the award made by the tribunal, and, consequently, mining operations at Broken Hill are considerably restricted.

Following the recommendations of the commission, all workers are medically examined before engagement, and while this precautionary measure will no doubt prove beneficial to the owners and the miners, it has, temporarily, caused a shortage of skilled workers.

The smelters at Port Pirie, South Australia, where the lead concentrates are treated.

In the early days, when oxidized and very rich sulphides were mined, the ores were smelted direct. When the primary, unaltered sulphides were reached, containing but from 12 to 15 per cent. lead, from 12 to 15 per cent. zinc, and 7 ounces of silver to the ton, it became necessary to concentrate the values in the ore before smelting.

Formerly, efforts were directed towards producing a lead concentrate from the ore—the other resultant products being:

	Lead per cent.	Silver ounces per ton	Zinc per cent.
Zinc middlings	4	3	16
Quartz tailings	1	1.5	5
Slime	10	7.5	12

The zinc middlings and the slime were stacked on the surface, as nothing further could be done with those ores with the means then available. The quartz tailings were either similarly piled or sent below ground to fill depleted workings.

Galena, sphalerite, rhodonite, calcite, and quartz are the chief minerals found in the ore as at present mined, but other minerals are found in varying quantities, as indicated by the following list:

Mineral	Percentage
Sulphides—	
Galena—lead sulphide	13–18
Blende—zinc sulphide	19–29
Pyrite—iron sulphide, Marcasite—iron sulphide, Phyrrhotite—iron sulphide	.5
Chalcopyrite—iron copper sulphide	.2
Free Silica—	
Quartz	14
Combined Silicates—	
Rhodonite, Sillimanite, Garnet, Mica, Feldspar, Augite, Hornblende	40
Carbonates—	
Calcite, Rhodochrosite	4

The usual procedure of gravity concentration in water was originally practiced—coarse crushing in gyratory and jaw breakers followed by rolls, the material from which was put through May & Hancock jigs which yielded a granular concentrate to the value of 65 per cent. lead. The pulp was then further crushed in tube mills or grinding pans preparatory to passing over Wilfley tables and Luhrig vanners, where a further extraction of fine-grained concentrate was made.

It was soon found necessary, in order to secure a good separation of galena, to crush the ore very fine, for even though the ore is a mechanical mixture of galena and blende the individual particles are very intimately associated. Fine crushing meant the production of slime, so that in course of years there grew up great dumps of zinc middlings, containing 3 per cent. lead and 16 per cent. zinc, as well as slime dumps holding 10 per cent. lead and 12 per cent. zinc. These middlings would not react to any further treatment by gravity concentration.

About twenty years ago the flotation

process was introduced in the Broken Hill district, and immediately the work of recovering the values from the are received a tremendous impetus. By the instrumentality of the various forms of the flotation process now in operation, the huge dumps of erstwhile waste material have, in the last decade or so, almost completely disappeared. Present-day milling practice consists of preliminary crushing and of the production of coarse-lead concentrate by means of gravity concentration in water. The residues are then crushed fine and treated partly by gravity concentration on Wilfley tables and partly by flotation—giving fine concentrates of lead and zinc. The point at which gravity concentration ceases and flotation commences depends upon the nature of the ore and can be determined only by careful experimental work.

The following is a list of the products yielded, together with their approximate values:

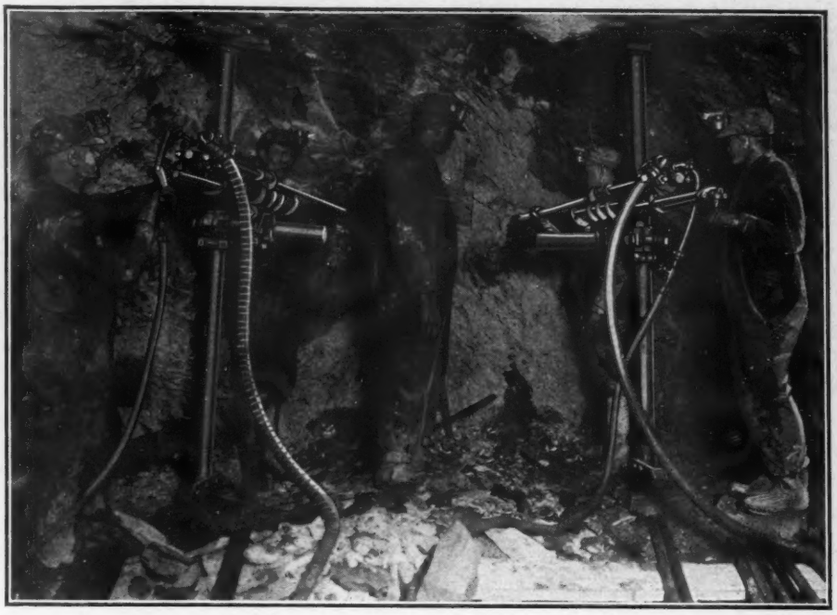
	Lead	Zinc	Silver
	per cent.	per cent.	ounces per ton.
Coarse lead concentrates	65	9	27
Fine lead concentrates..	55	12	45
Coarse zinc concentrate, made from direct flotation of zinc middlings	6	48	10
Fine zinc concentrate..	7	45	4

Lead concentrates are shipped to Port Pirie in South Australia, and are there smelted at the reduction works originally owned by the Broken Hill Proprietary Company, but now the property of the Associated Broken Hill Companies. A view of this plant is shown in one of the accompanying illustrations. About 3,000 tons of lead concentrates are now sent to Port Pirie weekly.

In the past, most of the zinc concentrates have been exported to England, Europe, and the East. During the war, however, this product was taken by the British Board of Trade and stored within the Empire, pending the completion of arrangements for smelting. The works of the Electrolytic Zinc Company at Risdon, Tasmania, in which the larger Broken Hill Companies have a considerable interest, are now in active operation and treat 100,000 tons of zinc concentrates annually.

Negotiations are now in hand for roasting most of the zinc concentrates at Port Pirie, where a large plant is under construction. The sulphur recovered is used in the flotation processes at Broken Hill and also in the manufacture of sulphuric acid for which there is a demand in Australia, particularly in the manufacture of superphosate.

There is being inaugurated in Australia an aerial mail service to traverse the wide reaches of the island, the points of call including many places now difficult of access. The climate and other conditions are practically ideal for the service, and we should look for substantial success for the enterprise.



A pair of "Leyner" drifters driving a 7x10-foot tunnel.

GREATER NATION-WIDE USE OF ELECTRIC POWER

A STATEMENT just issued by the Department of the Interior indicates a remarkable increase throughout the United States in the generation of electricity and in the efficient use of fuel. Electric public-utility power plants produced more electricity in 1922 than ever before, and over one-third of the total amount was generated by hydro-electric stations—thereby conserving more than 20,000,000 tons of coal. The State of New York leads in the production of electricity by public-utility plants, while California is preëminent in the matter of generating electricity by water power.

Within the past four years, 1919-1922, the average consumption of coal required to generate one kilowatt-hour of electricity was reduced from 3.2 pounds to 2.5 pounds—representing a saving of millions of tons of fuel.

A timbered portion of mine workings where square sets have been erected. An excellent example of protection against rock settlement.

NEW VARNISH PROOF AGAINST HEAT AND COLD

AFTER many years of experimentation, chemists have now developed a new finish for wood and metal that is claimed to be so durable, tough, and hard that it will resist high degrees of heat, hot or cold liquids, and hot plates or dishes. It is also said to be waterproof—in fact, it can be washed with soap and water.

The new material, which is known as "viscolac," is now in use in many wood and metal-working industries including the manufacture of automobiles and furniture. It is made of ingredients entirely different from those in the old-style varnishes. It is a "pyroxylin" solution developed from cotton; and it seems to have a natural affinity for wood and metal surfaces of all kinds.

It has been tested out under some of the most difficult conditions—even surviving the application of live steam. Chemists state that it does not readily chip or crack; that it is unusually hard and tough; and that it has the advantage, from a manufacturing standpoint, of "air drying" very rapidly.

Those responsible for the production of viscolac believe that it will completely revolutionize the art of wood and metal finishing. They point out the fact that tables and other household furniture coated with this new material are immune from the harmful effects of any kind of food or liquids spilled upon them. Automobiles surfaced with the viscolac type of enamel retain their original beauty much longer than those that are given a finish with the substances ordinarily employed.

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EDITORIALS

LINKING OUR INLAND SEAS WITH THE ATLANTIC

THE PROS and cons of the Great Lakes-St. Lawrence route to the sea have been discussed at length in the last two or three years. The public has been bewildered by an array of opposing data. The vast industrial empire of the Middle West has been unable to win the coöperation of other sections of the country in unlocking a water route which would inevitably benefit substantially the entire nation.

Strange as it may seem, foreign enterprise has come to the rescue. WILLIAM HANSEN of Bergen, Norway, the owner of a steamship line composed of vessels of 2,000 tons displacement, has concluded arrangements, so it is said, for the employment of sixteen of his steel craft in a Great Lakes-Atlantic service. According to the announcement, direct steamship sailings will be maintained between Chicago and Great Britain and ports of northern Europe. The service will be inaugurated on August 15, when the first of the fleet will leave Chicago bound for England.

We are told that the Chicago & Northwestern Railway will issue through bills of lading to the United Kingdom; and Mr. HANSEN'S American representatives declare that profitable cargoes for the westbound voyages have already been contracted for. Of course, it is recognized that the steamers to be used are relatively small; but if they make good they will establish conclusively the wisdom of taking such steps as may be needful to remove certain natural difficulties in the St. Lawrence that now prevent the employment of large transatlantic freighters. Millions of people will be interested in Mr. HANSEN'S venture.

IMPORTANT STEP IN COAL DISTILLATION

THE LOW-TEMPERATURE distillation of coal has engaged the attention of technicists in the United States and abroad for a number of years; and in this quest the aim has been to devise a process by which raw coal could be treated in a retort so as to leave a residue of marketable fuel and recover the while a maximum of the volatile matter carried by the coal. It has been realized that this end could be accomplished only by recourse to considerably lower temperatures than are now commercially used in the manufacture of coke. Partway success has rewarded some of these investigators, but none of the results has quite satisfied the theoretical standard which has been set.

The *Christian Science Monitor* has recently given considerable publicity to the work of Z. V. CARRACRISTI, of New York, who is said to have demonstrated in an experimental oven, erected in a corn field near Huntington, W. Va., that it is entirely practicable to distill coal in ovens of this type at a temperature ranging between 1,000 and 1,100° F. Further, it is claimed that it will thus be possible to obtain from a ton of coal—depending of course upon the character of the coal—as much as ten gallons of motor fuel. Be this as it may, the subject is one of tremendous importance, because it touches a matter of vital concern—a sufficiency of fuel at less cost than it is now generally to be had.

Five years ago, the Smithsonian Institution published a pamphlet by CHESTER G. GILBERT and JOSEPH E. POGUE entitled, *Coal: The Resource and Its Full Utilization*. In that able treatise, the authors stated: "Coal as now used fulfills three distinct and unrelated functions. It furnishes industrial power, material for the manufacture of coal products, and domestic heat. About two-thirds of the coal consumed in the United States goes into the production of power which is divided almost equally between the industries and the transportation systems; about one-sixth is used as a raw material for making substances employed industrially, such as metallurgical coke, upon which the iron industry depends, and gas, nitrogen compounds, benzol, tar, and coal-tar products. One-sixth approximately is employed for heating homes and other buildings."

But this resumé gives no hint of the appalling wastefulness ordinarily associated with the utilization of coal. When the householder shovels coal into the furnace or the fireman stokes his boiler, he generally throws away values of which he gives little heed, if he is aware of them at all. In other words, he squanders contained volatiles which do not help him and yet which, if recovered, could be put to a variety of profitable uses. Messrs. POGUE and GILBERT went to some trouble to show what might be the gains if bituminous coal were turned into a smokeless fuel by coking and the by-products conserved for other purposes.

Taking the 1915 price of soft coal as the basis for their calculations, that is, $1.13 a ton at the mine, they revealed that that coal, by a suitable system of low-temperature distillation, could be enhanced in value to $15.59! In other words, out of 2,000 pounds of bituminous coal there could be secured 1,500 pounds of smokeless fuel, worth $5; 10,000 cubic feet of gas, marketable at $9; 22 pounds of ammonium sulphate, which would bring 61 cents; 2½ gallons of benzol, valued at 75 cents; and 9 gallons of tar, which should fetch 23 cents. Just think of it, about $14's worth of commodities made available instead of being sent uselessly up the chimney!

Whether or not the Carracristi oven be the long-sought solution of the problem of low-temperature distillation of bituminous coal, the public will await further news of that invention expectantly, because if he has succeeded where others have fallen short then he has radically altered the economic value of soft coal and dispelled for all time the bugaboo of the approaching exhaustion of our anthracite deposits.

A CONGRESSIONAL REPORT WITH A MEANING

OF STRIKING significance and value is the report made by the Joint Congressional Commission of Agricultural Inquiry. This Commission consists of Mr. SYDNEY ANDERSON, Chairman, member of the House from Minnesota, and Senators LENROOT, CAPPER, MCNARY, ROBINSON, HARRISON, FUNK, SUMMER, MILLS, and TEN EYCK. It is said that this body has conducted the most extensive inquiry ever undertaken—extending the scope of the work to the whole question of industry, banking, transportation, and agriculture. There were almost 3,000 experts on the staff; and the investigation has extended over a period of one year.

An interesting fact brought out is that of every dollar spent by the consumer an average of forty-nine cents or nearly half is absorbed in the cost of selling and distribution, and that but twenty cents of the dollar goes to the primary producer.

The Commission's conclusion is that there is no single factor in the price structure which can be said to be responsible for the big disparity in the producer's and the consumer's prices, and it recommends attacking every link in the chain of production, manufacture, and distribution. Emphasis is laid on the fact that much of the business of the country is done by very loose and slipshod methods. If all business enterprises, says the Commission, were as efficient as those that are now operating on the lowest cost basis the greatest reduction in the cost of living would be possible. The conclusion to be drawn is that the large profits made by certain concerns, which are severely criticized, are not necessarily proof of excessive charges but are really indicative of efficient management—that is, production at low cost. Commenting upon this, Mr. GEORGE E. ROB-

ERTS, the eminent economist of The National City Bank of New York, says:

"This fact is repeatedly demonstrated, but the public comprehends it so little that a showing of large profits usually is taken as evidence that the concern making them is charging excessive prices, although their prices may be lower than those of competitors that have difficulty in making any profits at all. So long as a considerable share of the required production of any commodity is supplied by inefficient, high-cost producers, the market price must be high enough to enable them to remain in business, and the low-cost producers naturally reap the benefit of this situation. They are not able to supply the entire market, or if they attempt to do so by underselling their high-cost competitors they are likely to be denounced and perhaps prosecuted as monopolists."

PROPHECY AND FULFILMENT

AT A TIME like the present, when opinions differ as to whether or not business has reached the peak of prosperity, it is well to review the opinions of experts, expressed in the latter part of the year 1921, on business prospects for the year 1922.

ELBERT H. GARY: "Readjustments and reconstructions are not complete. Difficulties still embarrass and disturbances threaten."

JAMES B. FORGAN: "The liquidation made necessary by the depression in business has resulted in heavy losses to many industries. It is impossible to state when we shall reach the end of this period or begin a new cycle of progress."

E. G. GRACE: "The restoration of activity, at least as far as domestic conditions are concerned, is prevented by the failure so far to readjust vital elements in the situation. While these conditions remain, money cannot be invested in the development of industry with any expectation of a reasonably safe return."

L. F. LOREE: "I fear we are in the midst of one of the worst panics we have experienced and that we have not seen the worst."

JAMES S. ALEXANDER: "No great or speedy revival is likely—1922 is likely to be a trying year."

DAVID FRIDAY: "It seems probable that American prices will be forced to lower levels by the international industrial situation."

WESLEY C. MITCHELL: "There is little to warrant the hope that the pace of improvement will soon become rapid."

GEORGE W. NORRIS: "There are few industries in which the volume of orders is sufficient to justify capacity operation of plants."

GEORGE E. ROBERTS: "The outlook for business in 1922 is not calculated to inspire enthusiasm. The blight of low prices hangs over the agricultural territory and affects the purchasing power of a great body of consumers. It is highly important that this situation shall be clearly understood because we shall not have prosperity again until it is changed."

EDWIN R. A. SELIGMAN: "I do not look for a very speedy revival in general business during 1922."

PAUL M. WARBURG: "I believe today, as I did a year ago, that a determined general upward trend of trade and prosperity cannot be hoped for until the reparation question is solved in a practical manner."

In the matter of fulfilment of these prophetic utterances, however, the record for 1922 actually reveals:

1—Recovery in production and in trade from the severe crisis of 1921 appears to have been one of the most rapid of which we have any record.

2—Huge increase in bank deposits.

3—Greatest rise in commodity prices of any peacetime year in at least half a century or more with the exception of 1919-1920.

4—Greatest building boom in our history.

5—Greatest bond market in more than a generation; a huge rise in stocks; and an enormous distribution of stock dividends, etc.

6—Record production in fifteen or more important lines of industry, including an unprecedented output of automobiles.

7—Finally, in the latter half of 1922, a general rise in wages; numerous reports of a labor shortage; and a serious shortage in transportational facilities.

HALF CENTURY OF THE TYPEWRITER

PERHAPS the typewriter has not wrought the same revolutionary practices in the conduct of business as has the telephone in the course of its practical service, but no one can deny that the typewriter has proved a boon wherever it has supplanted the laborious and often illegible work of hand and pen.

The Herkimer County Historical Society has recently published an informative and copiously illustrated *Story of the Typewriter*, and in doing so has traced the evolution of this mechanical aid and, incidentally, has emphasized the fact that the writing machine in a commercial form will be 50 years old in September.

In Ilion, N. Y., at the plant of E. Remington & Sons, was first produced in 1873 a really marketable typewriter suited to the needs of commercial houses and other concerns desiring to speed up the preparation of a growing correspondence which was sorely taxing the capacity of the "pen driver." Since then, wonders have been wrought by many in rounding out, in amplifying, and in perfecting the diversified characteristics of typewriters such as we have today.

TO CHRISTOPHER LATHAM SHOLES most credit is due for the conception of the original so-called Remington machine. His inventive genius tided him along in the face of innumerable difficulties and frequent discouragements, and his grim determination to devise a workable apparatus finally won him success. Even so, there were times when the outlook seemed dark, and on one of these occasions he wrote to an associate: "You know that my apprehension is that the thing may take for a while, and for a while there may be an active demand for it, but that, like any other novelty, it will have its brief day and be thrown aside." As we know today, his prophecy was, fortunately, at fault.

Despite the much that the writing machine has done in taking the place of the pen, its most radical effect has probably been the opening up of a tremendous field of service to the woman worker. The naturally nimble feminine fingers soon disclosed a special aptitude for the tapping of the black-and-white keys; and through the instrumentality of the typewriter woman has advanced to a noteworthy status of "economic independence." The typewriter has given her contacts—a chance which she has not been slow to profit by.

WILL GLACIAL HISTORY REPEAT ITSELF

WITH THE hot sun making life miserable for millions of us, it is something of a relief to contemplate a possible return of the glacial era which at six different times, during the existence of this globe of ours, held much of the northern hemisphere in its icy grip.

Just what induced those frigid periods has not yet been made clear by the geologists; but it has been suggested that either the sun was temporarily blanketed by spots which veiled its radiated heat or that the earth wandered from its accustomed path around the sun. Scientists in Washington have recently told us that the temperature of Old Sol has dropped latterly; and there are others who point out that the recent, unusually chilly May was due both to the slackening efforts of the sun and to the beginning of a seventh ice age.

It may be that the situation will not, within our ken, do more than perpetuate the present fashion in summer furs; but trouble hunters, concerned about the future, may take comfort in the fact that an ice age does not reach much more than robust babyhood in less than 100,000 years. Of course, these glacial inundations, which cover intervals ranging from 500,000 to 1,500,000 years, have a way of making their proximity profoundly felt.

Whether or not the Arctic ice cap is spreading, there is probably no doubt that the quantity of ice in the polar regions has an influence upon the climatic conditions of the contiguous temperate regions—if not farther towards the equator. According to Captain ROBERT A. BARTLETT, a veteran of the Arctic Seas: "The weather along the Atlantic coast, in my opinion, is regulated by the ice cap. Last winter was the worst in years. The winds were generally northwest, and the ice and the wind together diverted the Gulf Stream, forcing it eastward and away from the coast. The chill felt here in May was, in part, due to that. There ought to be more radio stations in the Arctic to broadcast knowledge of those weather conditions which influence our shipping and our fishing."

Captain BARTLETT's suggestion merely emphasizes the amplification of facilities and work which already have to do with meterological research in circumpolar regions. It is realized by the experts that weather conditions in North America and Europe may be greatly influenced by both air pressure and accumulations of ice within the area of the Far North. Plans have been formulated for the establishment of observation stations, equipped with radio, in Northern Siberia, Spitzenbergen, and Greenland; and from these points of vantage it may be practicable to forecast the advent of winter and to gage fairly accurately its probable severity or mildness. Similarly, the data so gathered will enable the weather sharps to tell

us what to expect during the other seasons. This would prove a boon in many ways; and would likewise serve to quiet any alarm lest another ice age be upon us.

BRAKES ON AIR-BRAKE INVENTORS

IT IS a familiar experience in the development of mechanical inventions that getting a device to actually work is only the beginning rather than the completion of the inventor's task. This seems to be the present stage of development of the air brake for the front wheels of the automobile.

Everyone can see the desirability of brakes for all the wheels; and inventors by the hundred can tell us how, in various ways, to construct and to apply them to the front as well as to the rear wheels; but when we come to think of it they may be offering "too much of a good thing"—an added element of danger rather than of comfort and safety.

It will never do to make it possible to block the wheels, for with the front wheels locked there would then be no steerage control, and with the brakes applied to all the wheels the skidding danger would be aggravated. Under different conditions of load and of speed the brake pressure requirements must also vary; and it will not do to make it possible to exceed this desirable or permissible pressure as long as ignorance or recklessness so generally prevails among operators.

The brakes which are being developed and applied require a most careful and persistent try-out before permanent adoption; and we must not be impatient or too urgent as to the final result.

GOING ABROAD FOR FRESH FISH

THE GREATEST of French fishing ports, Boulogne-sur-Mer, is now receiving fresh fish from two new and distant sources. Frozen Canadian salmon has latterly gained an important place in the French market; and twenty tons a month is being handled there.

For the first time in the history of the French fishing industry an effort is being made to bring into France fresh cod caught in the waters off the coast of Iceland. Heretofore, the owners of vessels in the native fishing fleet have considered Icelandic waters too far away and were content to carry the salted article only. However, unsuccessful fishing off their own coast has prompted the development of a flotilla of fast steam vessels to exploit the fishing banks of Iceland. So much for what it is possible to do in the way of transporting perishable foodstuffs if a plenty of ice is available.

AN INVERTED ENGINE

An aero engine, known as the inverted Napier "Lion," has been tested recently at the Napier Works, Acton, Middlesex, England. It has been built for a two-seated, fighting'plane, and is a complete reversal of the ordinary engine.

Its crank case is at the top; its cylinders are beneath; and it is arranged so as to enable the pilot to have an unobstructed view forward of his machine. The engine developed 450 H. P. at the test.

MAKING LETTERS PAY, by Edward H. Schulze. A work of 455 pages suitably illustrated. Published by D. Appleton & Company, New York. Price $5.

IN THESE days of voluminous correspondence, when millions of letters are sent broadcast in an effort to establish business relations and to expand them, it is a matter of prime importance to the man that pays for those outgoing letters to win as large a return as possible from this means of appeal. All too many commercial houses are brought face to face with the fact at intervals that their letters fail of their purpose—seem to be wofully lacking in "pulling power." It is safe to say that all these concerns would be only too glad to see the tide turn and to have a fair measure of their letters bring in profitable responses. While it is doubtful that anyone can prescribe a system of letter writing which will be universally successful, nevertheless there are forms and ways which will do much towards arresting the attention of a reader and arousing in him a responsive spirit.

The author has had years of experience and has focused his accumulated knowledge in the present volume. However, in his opening paragraph, he sounds this warning: "To get the best results from *Making Letters Pay* it is vitally important that you use it in the right way." The book is full of valuable suggestions and can be read to advantage by anyone active in this line of endeavor.

A SYMBOL OF SAFETY, by Harry Chase Brearley. A book of 290 pages, with numerous illustrations. Published by Doubleday, Page & Company, Garden City, N. Y.

THIS BOOK is a comprehensive review of the splendid work done under the auspices of the Underwriters' Laboratories, Inc., and is designed to give an idea of the extent, the diversity, and the significance of the activities of that American organization. The story has not until now been told, and the subject is one that reaches into every home and into every department of industry either directly or indirectly.

Needless to remark, the primary object of the organization is to protect humanity through precautionary measures which will reduce hazards; and the book brings out vividly how much has been achieved towards this end by scientific research in a variety of directions. Also, the author sounds a warning. He says: "No sooner have we seized upon some new facility than we are likely to learn that nature may exact a serious price for its use. One evidence of this is found in fire losses which, in the United States, increased more than 1,000 per cent. between 1865 and 1922, while the population increased but 200 per cent. A study of fire causes shows that a large part of that loss can be traced to comparatively new devices and processes. The marked increase in loss of life and in bodily injury through accident is another result of material progress. Such things are inevitable but they are not necessary, which is merely a paradoxical way of stating that our swiftly developing civilization thinks more of using than of safeguarding; they are inevitable only so long as this state of mind holds control."

SPECIAL STEELS, by Thomas H. Burnham, M. I. S. I. A book of 194 pages, with illustrations. Published by Isaac Pitman & Sons, New York. Price $1.70.

THE METALLURGIST has shown that it lies in his power to produce steels of a wide variety possessing characteristics which make that metal especially suited to numerous particular needs. It should, therefore, interest a wide circle of readers to learn how steels for special purposes can be made and used to advantage.

Sir Robert A. Hadfield has pointed out that a fuller knowledge of the possibilities of steel make it practicable to save much metal that otherwise would be employed for certain structural purposes. He says: "For example, one ton of my manganese steel will do the work of about ten tons of ordinary iron or steel, owing to its increased durability and other qualities. In the same way, as regards my invention of low hysteresis steel, a ton of this steel is worth many times the weight of steel formerly used for similar electrical purposes."

STIMULATING THE ORGANIZATION, by Orline D. Foster. A volume of 414 pages. Published by Harper & Brothers, New York. Price $4.

THE AUTHOR has sapiently remarked in his foreword: "It is a supreme gift to be able to influence men. Wisely used it exceeds all expectations. The man who stimulates his workers only for his own selfish ends is a wastrel of his own power, but the man who has optimism, enthusiasm, and unlimited faith, who points toward the heights and paves the road for his workers to ascend, who cheers and encourages them on the way, reaps his reward not alone in the added fruits of their labor but in his recognition of the highest use of that great creative power which builds up the souls of men. For such leaders as these, this book has been written."

The book is full of sound common sense and stimulating suggestions which can be used to good account by executives in well-nigh every walk of business or productive life.

"Eliminate Risk and Waste," is the title of a pamphlet issued by The Keystone Lubricating Company of Philadelphia. This brochure contains useful information of value to the operators of machinery in many branches of industry, for it points out economies and gains in safety which can be realized through suitable lubrication.

The Year Book of the American Engineering Standards Committee, issued by that organization from its office at 29 West 39th Street, New York City, is now available. The book discloses that great progress has been made during the year gone in the standardization of subjects affecting mechanical engineering and the metal industries. As may be gathered, the

Committee undertakes to serve as a national clearing house for engineering and industrial standardization, to act as the official channel of coöperation in international standardization, and to provide an information service on engineering and industrial standardization matters. The economic potentialities of this work cannot be overestimated.

Standardization makes for ease of replacement, interchangeability, simplicity, and substantial savings. A single quotation from an address by the secretary of the organization will make this clear: "The purchasing agents of state and municipal government departments are spending approximately $700,000,000 yearly for supplies, materials of construction, and other products, . . . but these purchases are for the most part uncoördinated. In many cities and states perhaps half a dozen different departments may be buying the same materials at the same time but at different prices and under different specifications, or with no specifications whatever. Such a condition is, of course, conducive to great waste. Industry's purchases are even greater than those of state and municipal governments combined."

The United States Bureau of Mines announces the publication of the following bulletins and technical papers, which are now available for distribution:

BULLETIN 204. Underground ventilation at Butte, by Daniel Harrington. 1923. 130 pp., 3 pls., 42 figs.

BULLETIN 216. Bibliography of petroleum and allied substances in 1919 and 1920, by E. H. Burroughs. 1923. 374 pp.

TECHNICAL PAPER 283. Tests of low-grade and complex ores in Colorado, by W. H. Coghill and C. O. Anderson. 1923. 67 pp., 4 figs.

TECHNICAL PAPER 314. Metal-mine fires, by Daniel Harrington, B. O. Pickard, and H. M. Wolflin. 1923. 20 pp., 7 pls.

TECHNICAL PAPER 318. Coke-oven accidents in the United States during the calendar year 1921, by W. W. Adams. 1922. 34 pp.

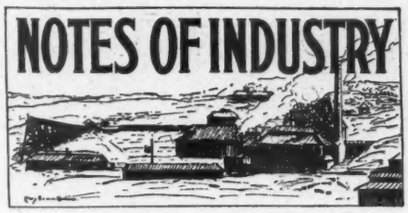
TECHNICAL PAPER 329. Quarry accidents in the United States during the calendar year 1921, by W. W. Adams. 1923. 90 pp.

MEASURING FINENESS OF PORTLAND CEMENT

IN ORDER to determine the fineness of Portland cement, there has been conducted at the Structural Materials Research Laboratory of the Lewis Institute, Chicago, Ill., a series of interesting tests which have established the fact that it takes 6,000,000 particles of cement to cover a surface one inch square.

In carrying out the tests, the cement was first passed through the standard sieve, which has 40,000 holes to the square inch. Samples of the screened material were then taken and blown by compressed air through a number of brass tubes. In this way the minute particles were graded and separated, after which it was possible to ascertain the sizes by microscopic measurement.

Just how fine cement dust is can be more fully appreciated when it is realized that but 600,000 bits of ordinary dust—comparatively speaking—is needed to cover a square inch.



Gaged by man power, road building is the biggest industry in the United States. The iron and steel industry employs 600,000 men; 750,000 operatives are engaged in the manufacture of automobiles; and 1,000,000 workers are busy building and maintaining our roads.

It seems incredible, but we have it upon the best of authority that 12,889 miles were drilled in the United States in 1922 in search for oil. Wells to the number of 24,000 were sunk, and these, if combined in one deep well, would have penetrated the earth to China and back again half way. About 79 per cent. of the wells drilled were producers.

Recent investigations reveal that the total available water power in Ireland is estimated at approximately 500,000 H. P.

Work has been started on the railroad that is to connect Mexicali, capital of the northern district of Lower California, with the Port of San Felipe. The line will have a length of 248.5 miles; and the road is to be in operation in three years. It is expected that the system will be of enormous benefit to the region, where famous mines and oil fields are located.

Several million school slates are manufactured in the United States each year, and about 90 per cent. of them are exported.

More iron ore was mined in 1922 than in 1921. The Chattanooga and the Birmingham districts made gains of 126 per cent. and 73 per cent., respectively, and the output of the Lake Superior district was 58 per cent. bigger. The Adirondack district was the only one that produced less ore in 1922 than in the year preceding.

According to the American Railway Association, a total of 1,014,029 cars was loaded with paying freight during the week ending May 26. This is not only the largest loading ever reported for any one week at this season of the year, but it has been surpassed only twice before in our history. But just wait until we get busy.

Announcement was made recently by the manager of the Santa Fe Railroad that more than 400,000 tons of ice will be used by his road alone in transporting some of the season's fruit crop from California to Chicago.

Additional grain-handling facilities are rapidly being provided at Vancouver, B. C., and it is estimated that by 1925 the port will have elevators capable of handling from 4,000,000 to 4,500,000 bushels.

The Government Iron Works at Yawata, Japan, has begun the manufacture of tinplate. While the present product is inferior to the imported commodity, due to an inability to turn out iron sheets of a uniform thickness without flaws or cracks, it is believed that this drawback will be overcome in time and with the greater experience of the workmen.

Shipments of copper bars from the Antofagasta district of Chile in 1922 amounted to 73,532 metric tons, and this quantity is thought to be the largest ever exported in the history of the industry.

A new belting, recently invented in Denmark, is manufactured from flax instead of cotton and is impregnated with certain chemicals which make it especially resistive to water, acids, etc., thus permitting its use out of doors in all kinds of weather.

To help the iceman to cut up artificial ice into cakes of standard size and weight for the consumer there has been devised a machine that scores the big 300-pound blocks as soon as they are frozen. An arrangement of saws rapidly cuts the cake in two directions to the desired size; and it is then a simple matter for the iceman to separate the pieces with his pick.

The first hydro-electric tramway in the world was opened to public traffic just 40 years ago—some years before its time as things have since developed—by Earl Spencer, then Lord Lieutenant of Ireland, at the Giant's Causeway. The originator of the scheme, and also the engineer and constructor of the line, was William A. Traill. The run was eight miles long, with heavy gradients, and power was obtained from a waterfall on the River Bush.

The Ever-Tyte Piston Ring Division, Walter A. Zelnicker Supply Company, St. Louis, Mo., recently adopted the sales policy of appointing distributors of their product who have mechanical experience and who are calling on the trade selling non-competitive lines. The concern has found this plan profitable both to themselves and to the distributors. The company expects to take on enough distributors during this season to cover the entire field.

A new resin of practical value in modern industry is announced from Mexico, and is the product of a tropical tree called *Cuapinoli*. It is of such quality that it can be used in the manufacture of the finest varnishes, and possesses the peculiarity of being insoluble in either alcohol or gasoline.

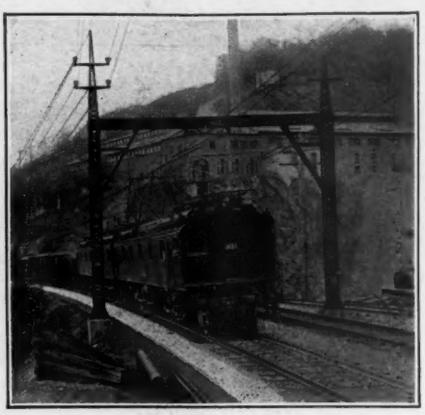
There is a great demand for paraffin in Mexico where candles are universally used by the poorer classes for lighting purposes. The houses of the better class, although furnished with electric lights, always have a supply of candles on hand for emergencies. Great quantities of paraffin tapers are also consumed in the churches; and it has been estimated that in normal times candles to the value of 10,000 pesos a month were burned throughout the republic for devotional purposes.

Spending $15,000,000 to Electrify a Busy Stretch of the Virginian Railway

IN ORDER to increase its traffic capacity and to secure important operating economies, the Virginian Railway has decided to electrify 213 miles of its track lying between Roanoke, Va., and Mullens, W. Va. This undertaking will involve the expenditure of $15,000,000; and the contract for the electric locomotives, power house, transformer stations, and other apparatus is the largest railroad electrification award ever made. The division to be electrified crosses the Allegheny Mountains, and an alternating-current, single-phase system will be used.

Ever since it started operations in 1909, the Virginian Railway has been an outstanding exponent of mass transportation, that is, the handling of traffic by means of an equivalent number of small trains. As a matter of consistent policy, the management of the road has regularly increased the size of its trains with every improvement in railway equipment until today this line is operating the heaviest trains in the world and hauling them by the most powerful steam locomotives. The electrification now to be undertaken is but the next logical step forward in an effort to maintain its standard of service at low ton-mile costs.

"With its present equipment," so we are informed by Frank H. Shepard, Director of Heavy Traction for the Westinghouse Electric & Manufacturing Company—to which concern the contract has been awarded, "the Virginian is moving 7,000,000 tons of coal per annum, but this capacity is not enough to take care of the growing demands of the area served. To obtain additional capacity by still further increasing the size of the trains is no longer possible with steam operation, for the simple reason that the limit in the power of the steam locomotive has been reached. Hence, after thorough study, it has been decided to



The Norfolk & Western Railroad is equipped with electric locomotives like those that will be used on the Virginian Railway.

electrify this mountain-grade division, which represents the neck of the bottle of the railroad.

"The chief advantage of electric operation is the greater power that can be applied to each train. The largest steam locomotives now in use on the Virginian are the articulated Mallet type, with twenty driving wheels and four cylinders. Three of these huge engines are used to move 5,500-ton trains over the grades, but their combined power does not exceed 7,000 H.P., and their speed on the grades is only seven miles per hour. The new electric locomotives, however, developing 20,000 H. P. per train, will haul 9,000-ton trains up the grades at a rate of fourteen miles per hour; and it will be entirely practicable in the future to further increase this power so that 12,000-ton trains can be handled at the same speed.

"This work of electrification is one of the largest railroad improvements since the World War. It is undoubtedly the forerunner of many other undertakings of the same nature, because it is generally recognized that the traffic-carrying capacity of some of our leading trunk lines must be augmented, in order to take care of the demands upon them, and that electrification, in general, is the most practical method to achieve this end.

"A feature of the electric locomotives to be provided will be the use of regenerative braking on the down grades. This method of braking will not only reduce the wear on the brake shoes and the wheels and improve operating conditions, but it will also save 15,000,000 kilowatt-hours of electric energy in the course of a year.

"Power will be furnished by a 90,000-H. P. generating plant to be erected on New River. This plant will supply current of 88,000 volts to the main transmission line. For use on the trolley wire, from which the locomotives will draw their energy, this high-voltage current is to be stepped down to 11,000 volts by transformer stations placed at regular intervals along the line. On the locomotives, this potential is reduced to a still lower value for the operation of the motors."

A competition for light airplanes, something like soaring 'planes but fitted with light engines, is being conducted by the Royal Aero Club. The piston displacement will be limited to 750 cubic centimeters (45.75 cubic inches). A total fuel allowance of one imperial gallon will be made, and the weight of the pilot is to be limited to 168 pounds. The take off is to be from a hill and a triangular course, not less than fifteen miles in length, with a range of hills on one side. A prize of $2,500 is offered for the longest flight over 50 miles.

A section of the Virginian Railway, famous for its long coal trains and its monster steam locomotives. The latter are to be supplanted by great electric tractors. It is believed that the present tonnage can be doubled through electrification.